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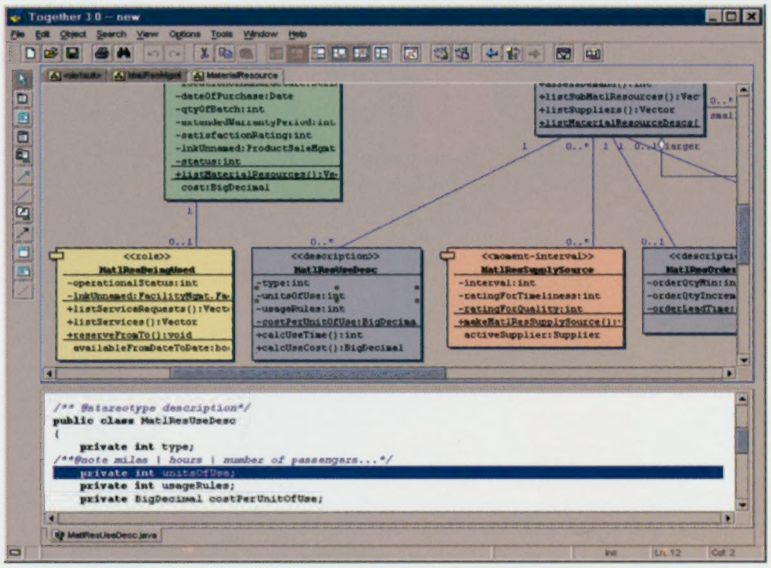

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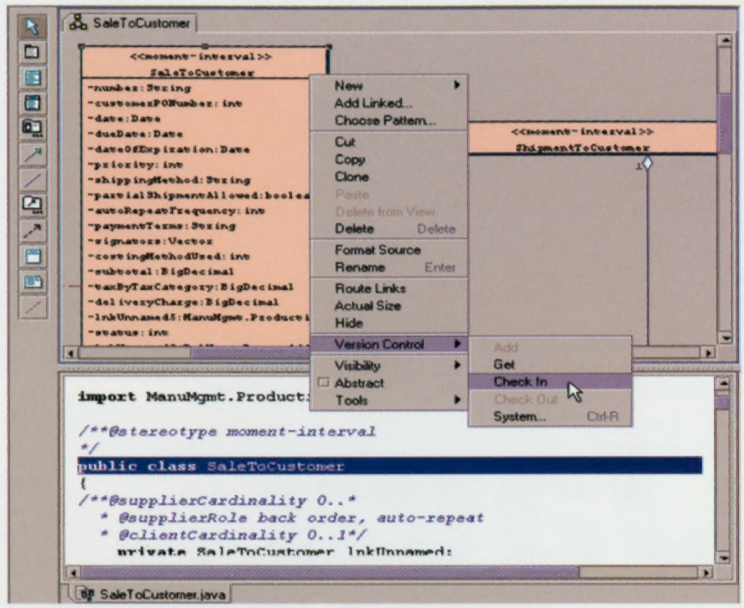

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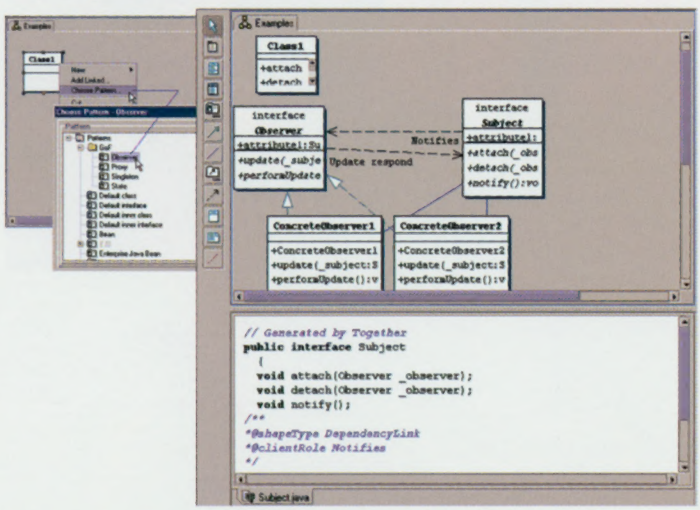

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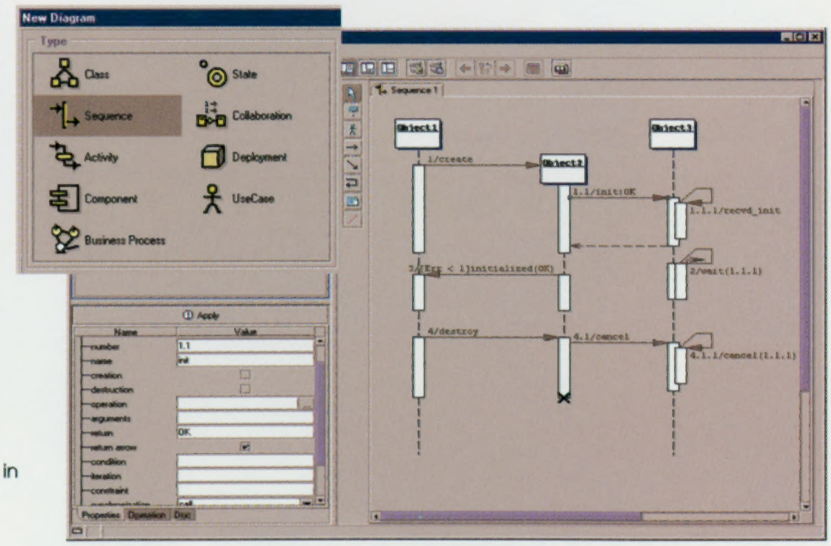

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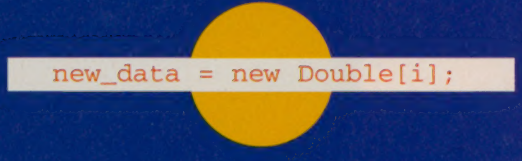

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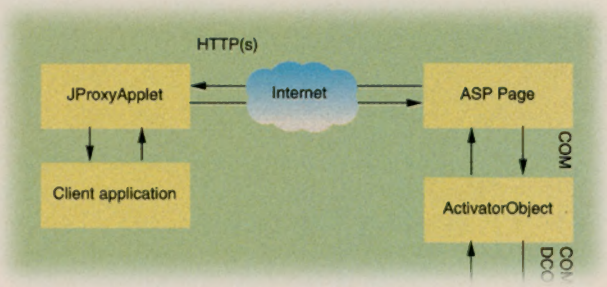

Your pure Java application can talk to a set of COM+ components; see page 34.

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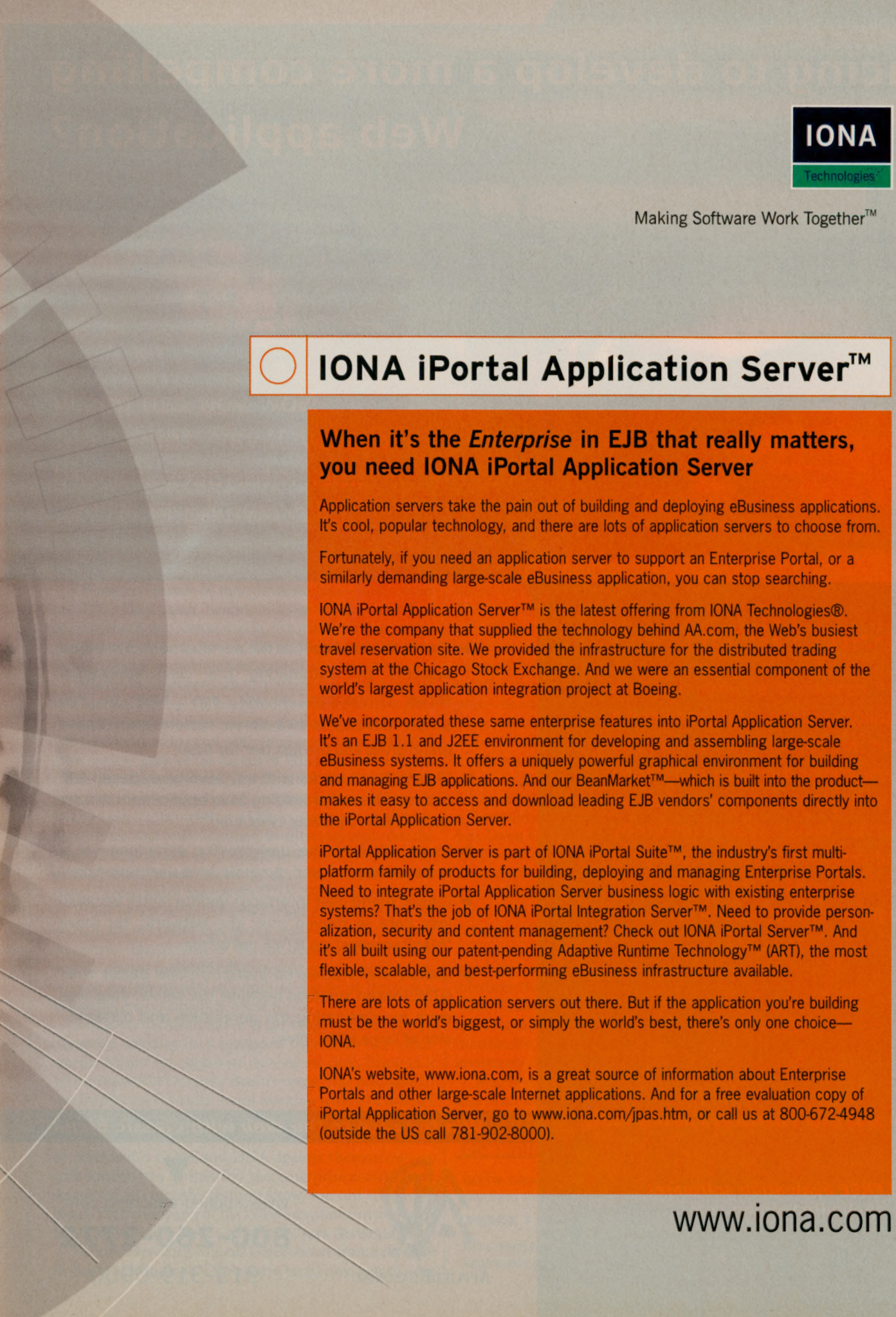

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When Worlds Collide

by Sean Gallagher
Editorial Director
sgallagher@fawcette.com

I never thought I'd see a day when Bill Gates parroted Scott McNealy, and Microsoft tried to restructure its development platform around an open standard. But both have happened in the last few months—Bill Gates talked about write once, run anywhere development tools, and the latest Microsoft vapor platform is based heavily on a rapidly emerging Internet standard. Talk about signs of an impending apocalypse.

Of course, neither of these involves Java—both center on XML. Then again, neither of these involves anything Microsoft will ship anytime soon. But it is ironic that, at this particular junction in history, the Microsoft and Java platform strategies would intersect in such an interesting way.

Whether we choose to admit it or not, much of the effort that has been put into the Java platform over the last two years has been to replicate the services and tools that Windows developers have had to work with. JavaServer Pages and JDBC even borrow parts of the names of Windows technologies. Others, like the Java Naming and Directory Interface (JNDI), match at some levels what Microsoft's platform offers—in JNDI's case, it's the new but widely unproven Active Directory Service. And while Microsoft loyalists may argue that the Java 2 Enterprise Edition (formally rolled out by Sun in December) is still mostly vapor, the same could easily be said about a great deal of Microsoft's DNA 2000 architecture.

While Java is definitely now a platform to be reckoned with, it doesn't mean that Java is ready to be all things to all people. The desktop is still the domain of Windows, and it's almost inevitable that any corporate application, written in Java or not, will find its way to or through a Windows environment in some form.

Religious platform fervor is for those without an application backlog or a ravenous user base—in other words, it's not for corporate developers. Still, living in a Windows world certainly doesn't mean that you have to live by Microsoft's rules—and working with Java doesn't mean you can't play with Bill Gates's toys when they fit the bill for a solution. In fact, it's possible to turn the tools of Microsoft's COM and DNA against themselves—as components of a (primarily) Java enterprise architecture. As two of this month's features show, you can effectively hijack the better parts of the Windows platform and turn them into resources for almost pure Java development.

In our cover story, Marcus Daley shows essentially how to hoist the Windows NT platform on its own petard—by turning Microsoft Transaction Server into a pure Java transaction processing server. Bill Block and Jerry Brunning describe bridging Java and COM objects through an XML interface, exposing data and methods trapped in the Windows world to Java developers.

As Microsoft continues to move its strategy more closely in line with that pioneered by Java, you can expect to be able to scavenge even more from the Windows world to help deliver Java-based solutions. Microsoft's XML strategy isn't necessarily a challenge to Java as much as it is an opportunity for Java developers to put Windows in its rightful place within the enterprise—as one operating system choice among many available in a multivendor environment.

Microsoft's XML strategy isn't necessarily a challenge to Java as much as it is an opportunity for Java developers to put Windows in its rightful place within the enterprise

Microsoft doesn't have to put a knife to its own throat for this to happen either—other vendors will certainly help open a vein or two. Lotus, for example, has just bundled in a COM interface to Domino. That doesn't seem like much of an entrée for Java. However, when it's combined with Lotus and IBM's support for Java through the Domino/WebSphere bundle, it provides a way to make back-end, Java-based services accessible to Windows clients through the COM interfaces that Windows developers are used to. And it provides Windows tools leverage. In fact, the Domino COM interface could make it possible for organizations to move away from the Microsoft platform on the server while keeping their investment in the Windows client intact.

Maybe this wasn't the kind of "embrace and extend" that Microsoft had in mind . . .

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Reviews

Tango 2000
JFC Suite 2.1

Tango 2000

Developing by Numbers

by Michiel de Bruijn

Quick Facts:

Tango 2000 is a capable visual development environment for data-driven Web sites, but will probably not live up to the expectations of Java developers used to more generic and open tools.

Pervasive Software
12365 Riata Trace Pkwy., Bldg. II
Austin, TX 78727
Phone: 800-287-4383; 512-231-6000
Web: www.pervasive.com
Price: $495

Pervasive Software's latest development environment, Tango 2000, scores fairly well on the buzzword-compliancy test: Whether you're looking for support for COM, JavaBeans, or XML, it's all in the box. Pervasive also promises that all this functionality is as easy to use as it will ever get.

Certainly *sounds* great—but before getting too excited, consider the target audience for the product: Web developers looking for a "drag-and-drop" solution to building complex Web sites. So, although JavaBeans *are* supported in Tango 2000, you're limited to using a scripting language to glue their functionality to other parts of the system. Which, although useful, is not quite what the average *Java Pro* reader looks for in a development environment.

Forget About Code

If you can accept that editing code is not something you'll do often—if at all—within the Tango editor, the product still has plenty to offer. In fact, you might find the visual approach Tango 2000 takes to application development pretty cool (see figure).

You start composing your Tango application by dragging items from the action toolbar on the left-hand side of the screen onto your workspace. All programming constructs are represented by icons, with action-specific properties accessible through property sheets. Some of the available actions are powerful: You can manipulate files on the host machine, send mail, or insert custom HTML code, which can include JavaScript code that uses variables from other parts of your program.

Tango 2000 puts a strong emphasis on database connectivity. By selecting a data source, the available databases and field will appear in a separate workspace, ready to be dragged onto the data components, such as the Search Builder, New Record Builder, or Direct DBMS component, which allows for manual construction of SQL statements. Transactions are fully supported, as well. One very useful aspect of Tango's data manipulation functions is that they have integrated support for XML, making it easy to communicate with other front-end or—especially—back-end processes that support this structured data standard.

Tango supports linking to COM and JavaBean components, although instantiation of objects tends to be slow. However, this feature works well, as long as the component supports the "assign value(s) to properties, invoke event, read properties" model.

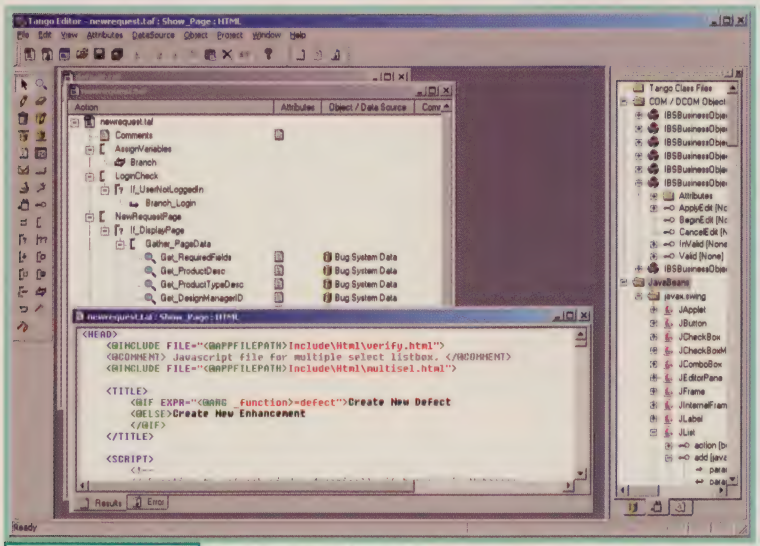
If you require more complex object interactions, you can write your own Java code (which you'll have to do outside the Tango environment, however) and execute it through something Pervasive calls its Java Action Server. This server module handles shifting data between the Tango code and your Java app, which needs to extend com.pvsw.tango.jas.Action and is obviously restricted in certain areas, such as its user interface.

Making Things Run

Deploying Tango applications requires the Tango Application server—a single-user copy is included with the development environment. Although the server components seemed usable and stable during testing, the relatively high cost of deployment combined with lack for real standards-based components may limit its attractiveness.

Other back-end components included with Tango 2000 are a Web analyzer, which provides detailed statistics on application usage, as well as a "workstation" copy of Pervasive.SQL. The latter is a fine relational database engine, but probably not a very exciting alternative for shops that have already invested in any other kind of ODBC-compliant database, especially since it seems to offer no specific functionality or performance enhancements when used together with the Tango editor.

Should you consider using Tango 2000 for your projects? If you're looking for a generic Java-flavored development environment that can be used to deploy to standards-based application servers, probably not. If, however, you must rapidly develop data-driven Web sites, especially using staff that has no extensive "real" programming experience, and you don't mind the product's proprietary structure, Tango may be ideal for you. ■



Cool Functionality Tango 2000's visual development environment enables you to build complex Web sites quickly using simple drag-and-drop operations.

Michiel de Bruijn lives in Rotterdam, The Netherlands, and spends his days as a networking and development specialist for an international media group. He seems to enjoy living on the bleeding edge of technology. Michiel always welcomes questions and comments: reach him at mdb@x42.net.

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JFC Suite 2.1

How Suite It Is!

by John Pearson

Quick Facts:

JFC Suite 2.1 enhances original JFC components, particularly JFCDataTable, JFCDataExplorer, and JFCDataCalendar. However, it is a bit pricey for small shops.

ProtoView Development Corp.
2540 Route 130
Cranbury, NJ 08512
Phone: 800-231-8588
Fax: 609-655-5353
Web: www.protoview.com
Price: $995 ($1,495 with Source Code)

Those who attended JavaOne in 1998 heard the announcement of the Java Foundation Classes (JFC). At the same conference, ProtoView announced the release of JFC Suite, its component suite to complement JFC. Now, more than a year later, Java continues to improve and develop. So, too, has the JFC Suite.

JFC Suite includes five major components: JFCDataTable, JFCDataExplorer, JFCDataInput, JFCDataTree, and JFCDataCalendar (see figure). All of these are all built on the Java Foundation Classes. Several of them are enhanced drop-in replacements for existing JFC components (for example, JFCDataTable is a drop-in replacement for JTree). All of the components are significant improvements over the originals.

JFCDataTable is an enhanced version of JTable. The first item that caught my attention was that you can print the entire table as well as selected rows. A print dialog and print preview dialogs are included. JFCDataTable has key mappings for several keyboard events (notably ESC, INSERT, and DELETE). For those who need more than a simple table, individual cells can contain other components, notably the JFCDataInput components. In addition, this component has other useful features such as sorting by columns and text searches (whole, string, or partial text). Because JFCDataTable is also a descendant of JPanel, it has other capabilities, such as notably enhanced colors, borders, and shadowing.

JFCDataTree, a descendant of JTree, is the next major component. It enhances the appearance of your trees by allowing more images per node (as many as six), customized indentation, customized coloring, dynamic node appearance, and drag-and-drop capabilities.

JFC DataExplorer is also a descendant of JTree, but it allows something JTree doesn't: You can drill down on data structures and display related data in the right-hand pane. You can add a grid, panel, or other components to make this a good way to organize and view data. In my genealogy application, I worked a bit on this to show family groups.

JFCDataInput is a library that contains a handful of data input components to make data validation easier. The components include JPVCurrency, JPVEdit (a regular edit box with some fun visual capabilities), JPVMask (a masked edit box), JPVNumeric (great for finances!), JPVTime (add this component and your application displays the time), and JPVPassword. For those who do a lot of work with dates, as I do, the DateEdit and DateEditLong components will be helpful. Additionally, a couple of other nifty components provide enhanced buttons, spinners, and labels.

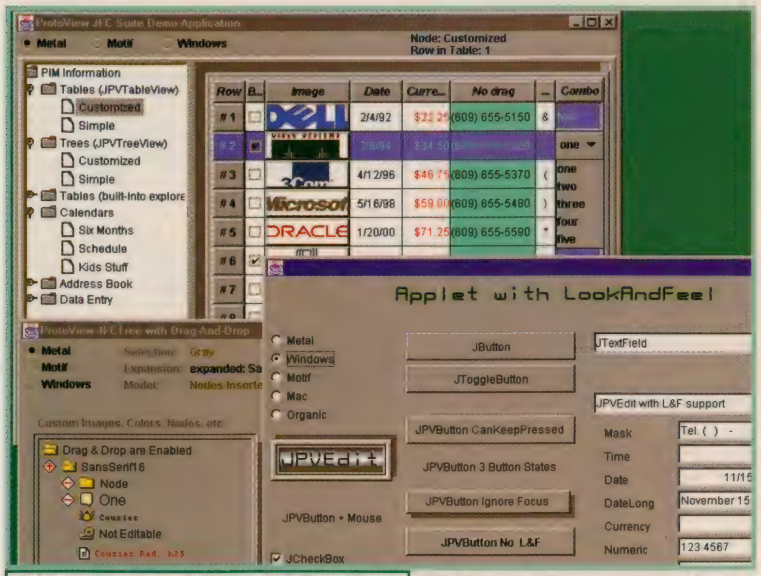
I have to admit, though, that my favorite components are part of the JFCDataCalendar. My hobby "program to end all programs" involves genealogy, so JFCDataCalendar has a lot to offer me. First of all, it's a calendar. It will show most of the dates you'll want to show (100 A.D. to 9999 A.D.), it allows for popup and pulldown dates, and it enables you to customize the contents of each cell. In addition to the generic calendar, it has two date selection components (JPVDatePlus and JPVDateLongPlus) that allow you to select dates from popup calendars.

In future versions, I would suggest that ProtoView add some sort of graphing capability—perhaps a 2D or 3D graph, a histogram (bar graph), and a way to point a couple of variables against an *x*- and *y*-axis. This would add to the product's appeal and make the price tag easier to swallow for small developers.

JFC Suite requires that the JDK 1.15 or JDK 1.2 be installed with JFC. However, ProtoView's documentation suggests that there may be a few anomalies with 1.15, so they recommend 1.2. On my NT 4 system, it took about 9MB to install.

The online documentation is well organized and helpful. The sample programs and applets that are included are equally important for learning how to use these products. Live, in-person tech support is also a part of ProtoView's products. I have called them a few times and received accurate help very quickly.

ProtoView's JFC Suite 2.1 is a component library custom designed for programmers who want to add a touch of professionalism and a lot of user friendliness to their programs. The components work well, are not too large to be included in a small application, and are frequently just what you need. ■



Tables, Trees, and Validated Data Entry JFC Suite 2.1 has something for everyone who is interested in making programs more user friendly and data entry more accurate.

John Pearson develops software for Java and Web development tools. He has contributed to several magazines including *Visual Basic Programmer's Journal* and *Visual Developer*.

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CryptoAdmin 4.0

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300 March Rd., Ste. 304
Kanata, Ontario
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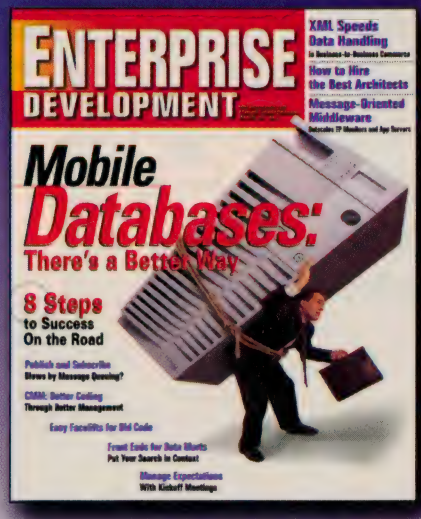
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203 ❑ Software architect
204 ❑ Software project leader
205 ❑ Project manager
206 ❑ Advanced technology evaluator
207 ❑ Software team leader
208 ❑ Software engineering supervisor
209 ❑ Systems analyst/designer
210 ❑ Database designer
211 ❑ Application manager/ administrator
295 ❑ Other (please specify)

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IS manager:
230 ❑ CIO, Technical VP
231 ❑ IS/MIS manager
296 ❑ Other (please specify)

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Application developer:
240 ❑ Applications developer/programmer
297 ❑ Other (please specify)

_____

Computer operations staff:
250 ❑ System Administrator
251 ❑ LAN Administrator
252 ❑ Help Desk
298 ❑ Other (please specify)

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Corporate manager:
260 ❑ CEO, president, partner, chairman, owner
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299 ❑ Other (please specify)

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401 ❑ Yes 402 ❑ No

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502 ❑ Database products?
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504 ❑ Middleware products?
505 ❑ Hardware servers?
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507 ❑ Testing/QA tools
508 ❑ Software process tools (Project/Process Management, Metrics, CM, etc.)
599 ❑ None of the above

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699 ❑ None of the above

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904 ❑ RPC middleware
905 ❑ Message Oriented Middleware
906 ❑ Application Integration Software
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910 ❑ Component software (VBX, OCX, ActiveX, custom controls, JavaBeans, etc.)
911 ❑ Configuration Management/ Version Control
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913 ❑ Process Management Tools
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920 ❑ 4GL Tools
921 ❑ OLAP, Data Mining or Data Warehousing tools
922 ❑ Reporting Tools
923 ❑ Web Authoring Tools
924 ❑ Expert systems/rules engines
925 ❑ Repository
926 ❑ Security Tools/Firewall Software
998 ❑ Other (please specify)

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999 ❑ None of the above

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If YES, which types?
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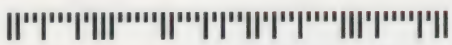

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Transform MTS into a Pure Java

Overcome critical cross-platform limitations by RMI-enabling the Microsoft VM

Marcus Daley is a senior engineer at Intel. He has been involved with Java development since its birth. In 1995, while working with Utah State University, he pioneered research into 3D modeling applications written in Java and VRML. Later, he joined a startup GIS company where he developed Java-based intranet solutions for small businesses and local governments. Marcus lives in Portland, OR, and can be reached at marcus@mdaley.net.

When Java programmers decide to build a Java component that needs to be hosted in an object monitor, most do not consider Microsoft Transaction Server (MTS) as a hosting environment. But MTS can be a reasonable—perhaps sometimes the best—solution for this distributed computing problem.

The problem is this: MTS is Microsoft's proprietary object monitor, and it was built to work only with Component Object Model (COM) components, which are Microsoft's answer to distributed object computing. However, COM components can be built in any language that supports Microsoft's COM specification, and Java is one of those languages. Java components running on different operating systems, particularly those using non-Microsoft virtual machines (VMs), must speak COM or DCOM to use MTS. This drawback can be critical when you build cross-platform clients.

To eliminate this problem, thus enabling MTS to become a Java component-hosting environment, you must RMI-enable the Microsoft VM. Combining the technologies of Java's Remote Method Invocation (RMI) API and the Microsoft VM into a simple proxy class enables any pure Java VM that supports RMI to call Java components hosted inside MTS.

Remote Method Invocation

Ever since RMI became a core part of JDK version 1.1 in 1996, it has been a valuable mechanism for performing distributed computing between Java components. RMI is similar to many distributed technologies such as RPC,

Object Monitor

by Marcus Daley

CORBA, and DCOM, but it does not inherit the level of complexity that surrounds those technologies.

RMI basically conforms to client-server methodology. For example, when you use RMI, usually a client invokes Java methods hosted by a server. The client and server are thought of as separate machines located on a TCP/IP-based network. However, they can both be located on the same machine or even in the same component.

When creating an RMI server, download a Java development kit that comes with the rmic and rmiregistry tools (see Table 1). These tools are not part of the Microsoft SDK, so you will need to download another Java development kit (such as Sun's) that contains them. And, since Microsoft's VM does not support RMI out-of-the box, you will need to download either IBM's or Microsoft's RMI patch for supporting RMI in Microsoft's VM. These patches can be found at http://alphaworks.ibm.com/tech/RMI or ftp://ftp.microsoft.com/developr/MSDN/UnSup-ed/. Please carefully read the licensing agreements before using either of the RMI patches or the tools in the Sun JDK.

One way to create an RMI server is to build the Java classes that will make up the implementation of the RMI server first (see Figure 1):

Tool	Function
Rmiregistry	A naming lookup service for RMI. The rmiregistry can be thought of as an online hashtable that associates names with distributed object references.
Rmic	A tool that generates skeletons and/or stubs used by clients and servers to facilitate distributed communication.

Table 1 Useful Tools When creating an RMI server, download a Java development kit that comes with these two tools.

```
// Standard Java class that contains the
// business logic

public class NameServer
{
  public String getName (String name)
  {
    return name + " has done it!";
  }
}
```

Next, create interfaces that contain the method signatures that will be exposed to the clients of the RMI server. These interfaces need to extend java.rmi.Remote, and each interface method must declare that it throws a RemoteException:

```
// Standard interface that exposes the
// methods available in the RMI server

public interface NameServerRMIInterface
  extends java.rmi.Remote
{
  public String getNameImpl (String name)
    throws java.rmi.RemoteException;
}
```

One of MTS's most appealing features? It's free.

For those of you who crave design pattern terminology, think of these interfaces as bridges that create abstractions, allowing the method signatures to remain the same while allowing the implementation to vary based on the RMI server.

Either a Java IDE or Sun's and Microsoft's Java development kit will work for developing RMI-capable client and server classes. When making an RMI server component that is hosted inside MTS, it is important to remember that all MTS-hosted Java components require Microsoft's VM (currently Java 1.1.7 compliant). This

Listing 1 Classy Servers RMI server classes must extend a RemoteObject subclass. In this case, the NameServerProxy class acts as the RMI server.

```
import java.rmi.*;
import java.rmi.server.*;
import java.rmi.registry.*;
// Special Microsoft Packages //
import com.ms.com.*;          //
import com.ms.win32.*;        //
////////////////////////////////

// This class extends and inherits standard RMI classes
public class NameServerProxy extends UnicastRemoteObject
  implements NameServerRMIInterface, Runnable
{
  // The thread that will be used to create an active
  // RMI registry and bind the NameServerProxy class to
  // the registry
  public Thread rmiThread;

  // This method makes a COM call that starts the
  // registry thread
  public static void main (String args [])
  {
    // Retrieve an IUnknown pointer
    IUnknown nameServerProxy = Ole32.CoCreateInstance
      (Ole32.CLSIDFromProgID ("NameServerProxy.1"),
      null, 4 | 16, new _Guid (
      "{00020400-0000-0000-C000-000000000046}"));
    // Call a subroutine supported by the object referred to
    // by the IUnknown pointer
    Dispatch.callSub (nameServerProxy, "startServer");
    // Release the IUnknown pointer
    ComLib.release (nameServerProxy);
  }

  // The parameterless constructor that must throw a
  // RemoteException
  public NameServerProxy ()
    throws RemoteException
  {
  }

  // The proxy method that accepts RMI calls and marshalls
  // them to the actual method on the NameServer component
  // via a COM call
  public String getNameImpl (String name)
    throws java.rmi.RemoteException
  {
    // Retrieve an IUnknown pointer
    IUnknown nameserver = Ole32.CoCreateInstance
      (Ole32.CLSIDFromProgID ("NameServer.1"), null, 4 | 16,
       new _Guid ("{00020400-0000-0000-C000-000000000046}"));
    // Make the call to the appropriate component and method
    // and retrieve a return value
    Variant result = Dispatch.call (
      nameserver, "getName", name);
    // Release the IUnknown pointer
    ComLib.release (nameserver);

    // We know that the return value was a String so
    // return the String value contained in the Variant
    // return value
    return result.getString ();
  }

  // Start a thread that starts the private rmiregistry and
  // binds the NameServerProxy class to the RMI registry
  public void startServer ()
  {
    try {
      rmiThread = new Thread (new NameServerProxy ());
      rmiThread.start ();
    } catch (RemoteException re) {
      re.printStackTrace ();
    }
  }

  // The body of the thread
  public void run ()
  {
    try {
      // Create a private registry on the standard
      // registry port
      Registry reg = LocateRegistry.createRegistry
        (Registry.REGISTRY_PORT);
      NameServerProxy rmiProxy = new NameServerProxy ();
      // Bind an instance of the NameServerProxy to the
      // private RMI registry
      reg.rebind ("NameServerProxy", rmiProxy);
    } catch (Exception e) {
      e.printStackTrace ();
    }
  }
}
```

means that MTS-enabled Java components cannot use any Java 2-specific technology (such as weak references, HashMaps, or the new Java 2 RMI security policies) unless Microsoft starts supporting the Java 1.2 specification. However, the Java clients of MTS components can use the Java 1.2 specification if the client's VM is 1.2 compliant (such as Sun's 1.2.2 VM).

RMI server classes must extend a RemoteObject subclass, the most common of which is the UnicastRemoteObject class. Server classes must also implement the special RMI interfaces. The constructor of a server class that extends UnicastRemoteObject must declare that it throws a RemoteException. Such an exception will be thrown at construction time if the class cannot be created or if a stub is not available. In the sample code in Listing 1, the NameServerProxy class acts as the RMI server.

To facilitate the distributed communication process, two classes must be generated by the rmic tool. These class files are known as the stub and skeleton classes. Their purpose is to marshal data between the client and server components. If the client and server are to work, the client must use a stub and the server must use a skeleton. Rmic generates the stub and skeleton class files when it is executed against an RMI server class that contains a RemoteObject implementation. To use rmic with the sample NameServerProxy class, just use rmic NameServerProxy. Once rmic has generated the classes, they must be locatable by the RMI server's CLASSPATH, and the stub must be locatable by the client's CLASSPATH.

Once the server code has been finished and the skeleton has been generated, a server instance needs to be registered with the rmiregistry. Start the rmiregistry server from the command-line or, programmatically, have the server start its own private registry. The sample proxy code in Listing 1 creates a private RMI registry in the run() method. If you start an RMI registry server within your own code rather than from the command-line, the RMI process becomes more transparent and tightly integrated into the MTS process. It also eliminates the need for a third-party rmiregistry executable (such as Sun's rmiregistry server).

Since the client component does not require extension of a specific super class or implementation of a special RMI interface, it is easy to implement. First, the client locates the rmiregistry and asks for a remote object by name. A reference to the remote object is returned to the client. Then the client casts the reference to the appropriate interface. At this point, the client can call any method defined in the interface as though the remote object were a local class instance (see Listing 2), although the implementation may be located halfway around the world.

Microsoft Java Extensions and MTS

Microsoft has been part of the Java community since it licensed Java in December 1996. Since then, Microsoft has built high-performance VMs that

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Listing 2 Easy Clients The client component is easy to implement because it does not require an extension of a specific super class or implementation of a special RMI interface.

```
// Standard RMI client that retrieves an object reference
// and makes a method call

import java.rmi.*;

public class RMIClient
{
  public static void main (String args [])
  {
    try {
      NameServerRMIInterface nsri = (NameServerRMIInterface)
        Naming.lookup ("//yourmachinename/NameServerProxy");
      System.out.println (nsri.getNameImpl (
        "Someone's name"));
    } catch (Exception e) {
      e.printStackTrace ();
    }
  }
}
```

rival many other VM distributions. Microsoft has integrated Java into many parts of its operating system and enabled the language to work with many Microsoft-centric technologies such as COM and ActiveX. When Microsoft integrated these technologies into Java, it included several Windows-specific packages as a part of its VM. Some of these additions are well-known and range from the new Windows Foundation Classes (com.ms.wfc.*) to the Windows API integration contained in the com.ms.win32 package.

The Windows Foundation Classes are a new set of classes Microsoft provided to build high-performance Windows-only applications. These classes allow experienced Windows developers to leverage their Windows knowledge while using Java to build Windows applications. While these new classes are interesting, they are not thoroughly discussed in this article. Instead, this article focuses on the Ole32 class contained within the com.ms.win32 package.

If used wisely, Microsoft's enhancements can add value to certain Java projects

Microsoft has provided a small subset of the Win32 API in the com.ms.win32.Ole32 class. This subset opens the power of Microsoft COM programming to Java developers building applications for the Windows platform. Methods contained within this class should not be difficult for advanced Windows programmers who typically use C/C++ or Visual Basic to write Windows applications using similar function calls. The same is true for Java programmers wishing to include this class and its associated methods within their Java code.

The code accompanying this article is written to achieve interoperability with MTS. If you are using MTS to service multiple VMs (including Sun's), these enhancements become necessary. Fortunately, use of the special Microsoft packages in this article has been carefully limited to a single proxy class that marshals RMI calls into COM calls (this is explained later in this article). When you use any of the com.ms.win32 classes, please keep in mind that you are tying yourself to the Windows platform in one form or another. In fact, Microsoft's special packages are a source of controversy and have drawn media attention over the last few years. However, if these Java enhancements are used wisely, they can bring added value to certain Java projects.

Microsoft's answer to the middleware space is MTS. In other words, MTS is Microsoft's Transaction Processing Monitor (TPO). MTS is a powerful TPO because it can host many COM objects in single or multiple processes (called packages) and manage the security rights of each process. MTS also provides a way to create out-of-process COM objects or even remote DCOM server objects.

One of MTS's most appealing features is that it is free. Although other, more costly, application servers are available from vendors that support CORBA and the Enterprise JavaBean standard, MTS is a solid and reliable solution for those projects that do not require those features. MTS is included in the NT Option Pack for NT 4.x and has been integrated into the Windows 2000 operating system as part of the Windows 2000's Component Services (otherwise known as COM+). Windows 2000 Component Services and NT 4's MTS work exactly the same on basic components without any alteration (as of the RC2 release of Windows 2000). Therefore, unless specified, both will be referred to as MTS.

Creating Java COM components that work within MTS doesn't require using confusing Microsoft compiler directives. In fact, pure Java developers should encounter nothing unfamiliar in the process. It requires only that you in-

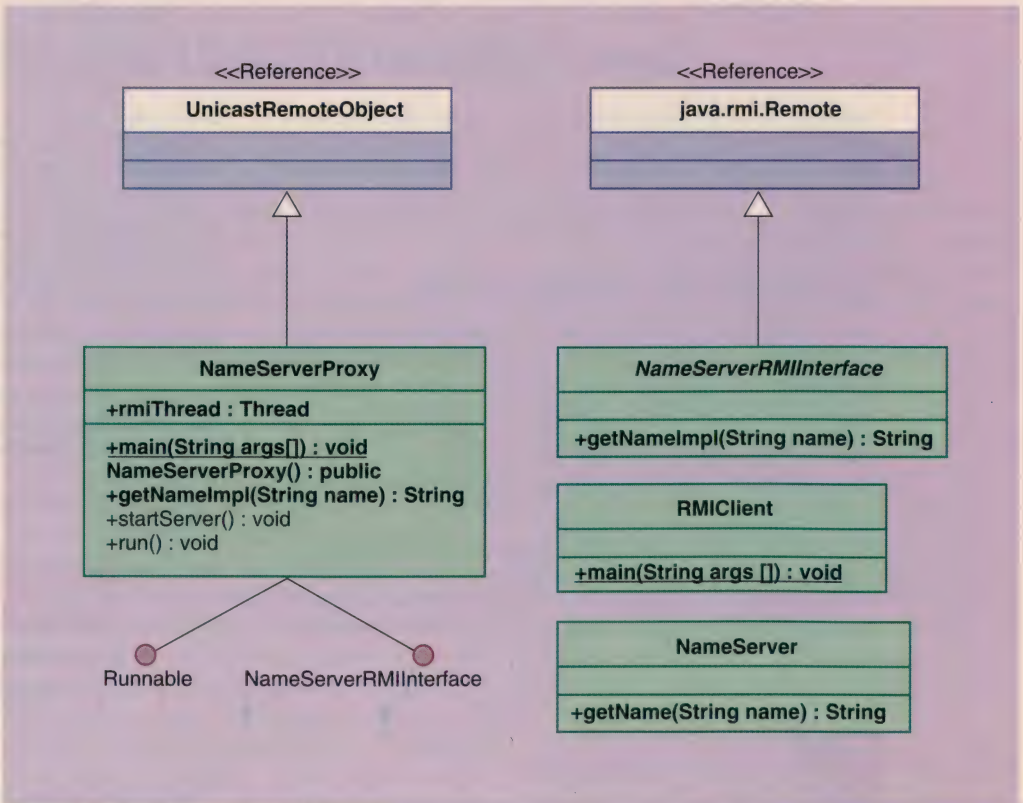

Figure 1 Class Relationships These are the class relationships in our RMI server.

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clude a few Java packages from Microsoft. You will also need to compile the Java proxy with Microsoft's compiler.

To begin, download the latest Microsoft Java SDK and VM from www.microsoft.com/java/. Once you install these two downloads, you are ready to create a Java COM object that can be hosted in MTS (I would also suggest installing the RMI patch now).

First, examine the NameServerProxy code shown in Listing 1. Two packages, com.ms.com.* and com.ms.win32.*, need to be imported from the Microsoft class files. Those packages enable a Java class to perform standard COM calls as though it were a Microsoft C++ or Visual Basic program. The first package, com.ms.com.*, imports the standard COM classes that are necessary to perform basic COM calls from Java (such as the Variant data type, Dispatch class, and IUnknown class). The second package, com.ms.win32.*, imports classes that represent the standard Win32 API calls and the Ole32 class. The Ole32 class contains many of the Win32 API functions that are used to create and manipulate COM component instances.

The proxy class (Listing 1) shows two methods that use these special Microsoft classes. Explanations for each class and method usage can be seen in Table 2.

Class or method	Description
IUnknown	Similar to the interface that refers to an object reference returned from an RMI call. IUnknown represents an arbitrary COM object.
Ole32	A Java class containing Win32 API functions that create and manipulate COM component instances.
_Guid	Represents a globally unique identifier (GUID). A description of how Microsoft creates GUIDs can be seen at: www.microsoft.com/asf/spec3/c.htm.
Dispatch	Provides a mechanism for Java programs to invoke methods on a COM object represented by an IUnknown instance.
ComLib	Provides static methods that can be used to control a COM object instance.
Variant	A common data type used in COM communication. It represents a union of several different data types such as integers, floats, booleans, strings, and so on.
Ole32.CoCreateInstance()	Creates an instance of a COM object represented by a GUID and returns a specific interface supported by that COM object.
Ole32.CLSIDFromProgID()	COM objects can be identified by a GUID and a unique, user-friendly name. If you know the user-friendly name of the COM object, then you can get its corresponding GUID using this method.
Dispatch.callSub()	Invokes a function on a COM object that returns void.
ComLib.release()	Releases an instance of a COM object. This implies that you will no longer be using the COM object.
Dispatch.call()	Invokes a function on a COM object that returns a Variant.
Variant.getString()	Returns the String value contained in the Variant union.

Table 2 Imported Goods The Microsoft class file package com.ms.win32.* imports classes that represent the standard Win 32 API calls and the Ole32 class.

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The first call to CoCreateInstance() method in the NameServerProxy class is found in the main method. CoCreateInstance()creates a COM instance of the NameServerProxy class by requesting it as NameServerProxy.1, its COM friendly name. The lengthy String value passed as the last parameter of the method is the String representation of a GUID. The GUID represents the IDispatch interface that is part of the NameServerProxy object. Once the COM component is created, the Dispatch class calls a subroutine on the COM object named startServer(). The startServer() method starts a Java thread in its own private RMI registry and registers the NameServerProxy class as an available RMI server. Finally, the ComLib class calls the release method by passing the IUnknown NameServerProxy variable as the only parameter. This causes the NameServerProxy Java COM object to be released, since it will no longer be used.

The getNameImpl() method of the NameServerProxy class acts as a surrogate method for the actual getName() method found in the standard Java NameServer class. Java classes using RMI that invoke a method found in the Java NameServer class call this method. The NameServerProxy class accepts these RMI calls and marshals them to the NameServer class by performing a COM call.

One thing to note in the getNameImpl() method is that the return type from the standard Java method in the NameServer class has become a Variant data type. This happened because all COM calls using IDispatch require parameters and return types to be supported in the Variant union. Since all of the Dispatch class methods return a Variant, you can capture any data type returned from a Java method that was invoked via COM as long as the return type is supported in the Variant union.

Any Java 1.1 Java compiler can compile the NameServer class. However, the NameServerProxy class must be compiled using Microsoft's JVC compiler found in its 3.2 SDK (this is because of the two Microsoft-specific packages). But how did the standard Java 1.1 class NameServer became a COM object without special recompilation or Microsoft extensions? And how did the NameServerProxy object became a COM object without becoming a DLL or requiring an IDL file? These things are taken care of by javareg, provided by Microsoft, which turns standard Java 1.1 classes into COM objects. This tool can assign a GUID, user-friendly name, and other interesting capabilities to the Java class. These features are supported by javareg's command-line options, for example: javareg /class:NameServer /register /progid: NameServer.1. This tool is located in Microsoft 3.2 SDK /bin directory.

That's how a Java class can become a COM component without recompiling or comprising its compatibility. After compiling the NameServerProxy class with the Microsoft JVC compiler, it also must be javareged in the same way that the NameServer class was. Doing this will also make the NameServerProxy class a COM object.

When using the javareg tool and the Microsoft VM, the Java classes become IDispatch-capable COM objects and magically inherit the IDispatch interface. The IDispatch interface is represented by the GUID seen in Listing 1. The IDispatch interface allows clients of a COM object to query the object to see what public methods it contains. In the getNameImpl() method, I assumed there was a method called getName() that required a single String parameter and would return a data type supported by the Variant union. If such a method signature had not existed, an exception would have been thrown and the code would have required a change. The code would be fixed to include a call to an existing method signature.

The IDispatch COM interface is the simplest way to use Microsoft's COM architecture. It is

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also the easiest way to achieve the RMI-over-COM marshalling required by MTS when non-Microsoft VMs are used.

Putting it all Together

So, how do we execute the sample NameServer class files? First, ensure that the NT Option Pack and the latest NT Service Pack are installed on your machine. An option in the NT Option Pack installation is to install MTS. (Select the MTS installation checkbox.) If you use Windows 2000, MTS is already installed in the form of the Component Services included in the operating system.

You will need to install the latest Microsoft SDK and VM, apply the RMI patch, and install a non-Microsoft VM that supports RMI (such as the Sun JDK 1.2.2). Installing a VM other than Microsoft's allows you to test the interoperability of multiple and differing VMs calling RMI methods on a COM object hosted inside of MTS.

The NameServerProxy class should be compiled using the Microsoft Java compiler (JVC). The other classes and interface can be compiled by any Java compiler you choose. These classes must be locatable in each VM's CLASSPATH, so make appropriate changes, if needed.

The javareg tool registers both the NameServer class and the NameServerProxy class and assigns them friendly names. Friendly names are called programmatic identifiers (progid) and are unique name mappings to a specific GUID. For convenience, I would suggest using the same friendly names as those included in the NameServerProxy code.

Once that is done, the newly registered Java COM objects need to be hosted within MTS, which is handled through the Microsoft Transaction Console (MTC) or Component Services Management Console (CSMC). Choose which tool you want, open it, double-click on the Computers icon, and double-click on the My Computer icon. This is where the two tools diverge. If you use the MTC (Windows NT 4.x), right-click on the Packages Installed icon and click New then Package. A dialog box will appear asking you what type of package you want to create. Click Create Empty Package and type the name of the package into the dialog box that appears (the name can be anything). Then, another dialog box appears that allows you to set security attributes on the package. Bypass this box by clicking Finish. The empty package is created.

If you use the CSMC (Windows 2000), follow the same steps with a few exceptions. The CSMC names are different, and you'll get a few additional dialog boxes. Right-click on the COM+ Applications icon and click New then Application. From there a dialog box will appear. Click Next, then click Create Empty Package and type the package name into the dialog box. Click Next (leaving the rest of the choices at their default state), then Next again, then Finish. This creates an empty package that will act as a host for any components you designate. The components are hosted in a process (package) called mtx.exe on NT 4.x and dllhost.exe on Windows 2000. These processes are standard processes that are managed through the MTC or CSMC.

To place the Java COM objects into the NameServer package (assuming you named the new package NameServer), double-click the package in the MTC or CSMC. Then, right-click the Components icon and click New then Component. In the CSMC, a dialog box will appear; just click Next. Then, in both the MTC and CSMC, click the Import Components button. Your computer should present you with a list that contains the progid of every COM component that can be hosted in an MTS package.

RMI does not inherit the level of complexity that surrounds RPC, CORBA, and DCOM

Search the list for the friendly names you assigned to the NameServer class and NameServerProxy class and highlight them. If you use the CSMC, click Next and then Finish. If you use the MTC, click Finish. At this point, both Java classes are hosted in the MTS package and you can access them like other COM components in the Microsoft operating system.

When you are finished, leave the NameServerProxy component properties as they are and change the NameServer component properties. To do this, right-click on the NameServer component and click the Properties option. A dialog box will appear that contains all available properties for the NameServer component (you can do many things to this component). Remember, the NameServerProxy component is only a proxy and should never contain business logic. You may want your NameServer component that contains all of the business logic to participate in or require a new transaction. Clicking on the Transactions tab in the Properties dialog box can set this property, or you can set security restraints on the COM object. If you use the CSMC, you can even set properties that pertain to the concurrency support for the component.

For fun, set the NameServer component to require a new transaction. This means that every RMI call to getNameImpl() will participate in a new transaction that starts when the getNameImpl() method marshals the RMI call to the NameServer Java COM component. You can also set other properties to use the capabilities of MTS.

Executing the Sample Code

Let's test the sample code and watch it marshal RMI calls over COM to Java classes hosted within MTS. You will notice that the main method in the NameServerProxy class can be run from the command line. This is important because the RMI server must be started and a registry (rmiregistry) must be instantiated for the client to make RMI calls to the proxy. To execute the NameServerProxy and start the registry, the NameServerProxy code must be executed using Microsoft's Jview tool. Jview is Microsoft's utility that executes Java applets and applications from the command line and is similar to the Java command-line utility that Sun provides in its JDK.

Execute the command-line procedure Jview NameServerProxy. Doing this will start the RMI server and prepare the proxy to accept RMI calls from clients.

Inside the MTC or CSMC, you can watch the state of the components change when they are called. Feel free to test the different views and learn what happens.

You can now execute the client code using a command-line utility—for example, java RMIClient. This helps validate that the RMI calls a client makes are properly marshaled into COM calls and into the NameServer component.

When the client is executed, it makes a standard RMI call to the RMI server hosted within MTS. The RMI server then propagates that call to the appropriate component hosted within MTS, and it returns a value as appropriate. The MTS component may participate in a transaction or a series of transactions before the return value is returned. Either way, the action is transparent to the client.

This solution may not be everyone's cup of tea, but MTS can be an inexpensive substitute for an Enterprise JavaBeans or cross-platform application server. By using this marshalling method, you can use MTS as a Java TPO. It meets many needs and has demonstrated the reliability and performance you expect from a TPO. Consider it when the time is right. ■

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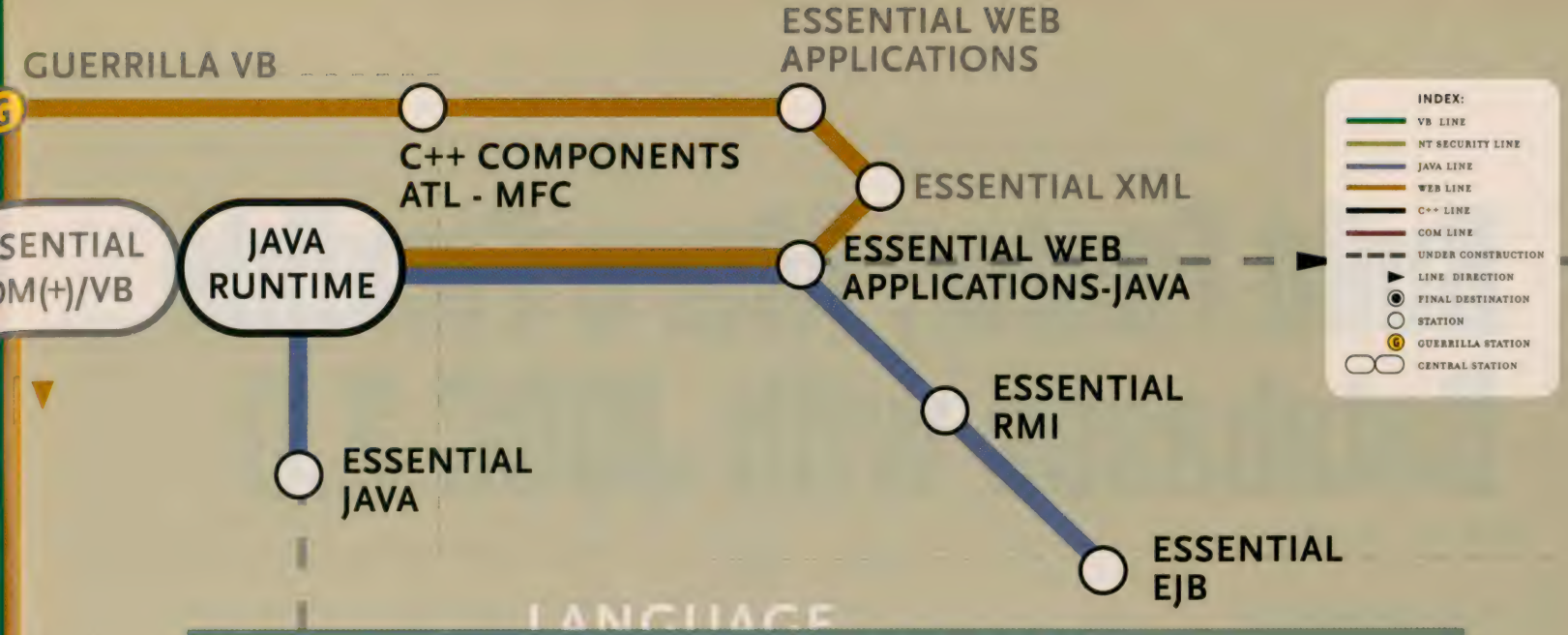

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Build Faster, More Flexible Databases with JDBC 2.0

The new connectivity standard improves both performance and functionality

by Brett Spell

What most people refer to simply as Java database connectivity, or "JDBC" is actually JDBC 1.2. Although JDBC 2.0 has been around as a specification for some time and is included with Java 2, most drivers didn't implement the new standard until recently. Now that such drivers are starting to appear, however, it's easier to implement the strengths of this new connectivity standard. In this, the first of three articles examining the many new features of JDBC 2.0, I'll examine the improvements JDBC 2.0 makes over the limitations of 1.2, and how the drivers implement them.

Let's start with a basic database scenario. For example, if your application needs to execute a series of Structured Query Language (SQL) statements to update information, you might code something like that shown in Listing 1.

Here, the first line creates an instance of a JDBC driver—specifically, the JDBC-ODBC bridge driver. The second statement obtains a connection to the database, and the next creates an instance of Statement and uses it to perform a series of updates. Note that each of the updates will be sent immediately to the database when executeUpdate() is called.

Similarly, if your application needs to read from the database, it could perform the same first three steps. However, instead of calling executeUpdate(), it might use executeQuery(), passing a SELECT statement as a parameter and getting back an instance of ResultSet. The result set maintains a pointer or "cursor" to one of the rows returned by the SELECT (initially pointing before the first row) and allows the user to move the cursor forward one row at a time by calling the next() method. For example, this code selects all rows from the INVENTORY table and prints out the string value stored in the second column of each row:

```
Statement stmt = conn.createStatement();
ResultSet rset = stmt.executeQuery(
  "SELECT * FROM INVENTORY");
while (rset.next()) {
  System.out.println("Item name " +
    rset.getString(2));
} // while (rset.next())
```

Performance Problems

One of the most common complaints about JDBC has been that it suffers from poor performance. Part of the responsibility for this problem lies with the interpreted nature of Java, but it's also related to the design of JDBC 1.2 and the drivers that implement it. For example, in the cases we just saw (which are typical of the way you would use JDBC), each one represents a situation where performance can be greatly improved:

- In the case of a SELECT, where we read rows from the database, the driver may request only a single row at a time from the database.
- Each INSERT, UPDATE, and DELETE statement issued through the executeUpdate() method is sent immediately to the database.

Listing 1 Needing SQL Statements If your application needs to execute a series of SQL statements to update information, you might code something like this.

```
new sun.jdbc.odbc.JdbcOdbcDriver();
Connection conn = DriverManager.getConnection(
  "jdbc:odbc:test", "bspell", "brett");
Statement stmt = conn.createStatement();
int result = stmt.executeUpdate(
  "UPDATE CUSTINFO SET STATUS = 1
  WHERE CUSTOMERNUM = 12345");
result = stmt.executeUpdate(
  "DELETE FROM ORDERS WHERE CUSTOMERNUM = 98765");
result = stmt.executeUpdate(
  "INSERT INTO INVENTORY VALUES (246, 'Chair')");
```

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These are really two variations of the same problem: each update and row retrieval requires a separate call to a database that typically resides on a different machine from the caller. In other words, each request generates a separate call across the network, and this is a problem because network communications usually involve a lot of overhead. Making many calls can be slow even with a very fast network, and database applications often do generate many requests. This issue isn't specific to database operations; it also becomes a factor in using distributed objects, such as with RMI, CORBA, or Enterprise JavaBeans (EJB). A simple and common solution to this problem is to group a set of requests and send them across the network in a single call. Even though the volume of data transmitted across the network will be about the same, this approach often improves an application's performance because network overhead is reduced.

At this point, you may be wondering how to group database requests. If you're using JDBC 1.2, the answer is that you can't, although the behavior specified for 1.2 doesn't prohibit the driver from pulling multiple rows across the network at one time. In fact, the documentation from JavaSoft states "We anticipate that drivers will normally prefetch rows in larger chunks so as to reduce the number of interactions with the target database."

This assumption, however, is problematic. For example, suppose your application performs a query that returns multiple rows, and the JDBC driver stores them in memory ("prefetches" them) until your application requests them. Let's also assume that another user modifies some of those rows in the database after the driver fetches them, but before your application reads them from the result set. Since the data prefetched by the driver is outdated, it will return information to your application that does not correctly reflect what is stored in the database. Depending on the transaction isolation level used, this may not be the expected behavior and can create problems for your application. (For more information on transaction isolation levels, see "Using Database Transactions In Java" in the September 1999 issue of *Java Pro.*) Still, many applications operate under the assumption that the data will not be modified while it's being read, or that such modifications aren't a problem. In those cases, it's acceptable for the JDBC driver to prefetch rows.

The problem with this is that when you're using JDBC 1.2, the application cannot specify to the JDBC driver that it should or should not allow prefetching. However, in JDBC 2.0, you *can* specify how many rows (if any) should be prefetched by the driver whenever more rows are needed. You can set this value by calling setFetchSize() for either a Statement or a ResultSet. Setting it for a statement makes it the default value for any result sets created by that statement, while setting it for a specific result set overrides the value "inherited" from its statement. For example, the following code sets a prefetch size of 10 for the statement, and that value is used by the first result set. The second result set then sets its own fetch size to 1, effectively disabling prefetching of rows:

```
Statement stmt = conn.createStatement();
stmt.setFetchSize(10);
ResultSet rset = stmt.executeQuery(
  "SELECT * FROM INVENTORY");
.
.
.
rset = stmt.executeQuery("SELECT * FROM CUSTINFO");
rset.setFetchSize(1);
```

One last point about the fetch size: this is simply a *suggestion* for the driver, which may or may not prefetch the number of rows you specify. Whether the driver does so depends entirely on the vendor's implementation. In some cases, prefetching may not be supported at all, but for drivers that do support this feature, setting the value appropriately can greatly improve the performance of your application. Even if you allow the driver to use prefetching, you still can ensure that you're not seeing outdated information, because JDBC 2.0 also provides a refreshRow() method that causes the result set to retrieve an updated copy of the current row from the database.

A driver can claim to be 2.0-compliant but still not support the features your application needs

Remember how each update statement such as INSERT, UPDATE, and DELETE is sent to and processed by the database immediately when the executeUpdate() method is used? If you've guessed that JDBC 2.0 also provides a way to send updates across the network in groups (or "batches"), you're correct. In fact, this feature is called "batch updating" and is very easy to use. Instead of using executeUpdate(), simply call addBatch(). Once you've added all the update statements that should be grouped together, use executeBatch() to send them to the database for execution. This code, which performs the same modifications as the code in Listing 1, illustrates this action:

```
conn.setAutoCommit(false);
Statement stmt = conn.createStatement();
stmt.addBatch("UPDATE CUSTINFO SET
  STATUS = 1 WHERE CUSTOMERNUM = 12345");
stmt.addBatch("DELETE FROM ORDERS WHERE
  CUSTOMERNUM = 98765");
stmt.addBatch("INSERT INTO INVENTORY
  VALUES(246, 'Chair')");
int[] results = stmt.executeBatch();
```

Note that in this example, we disabled auto commit mode before attempting the updates. You'll normally want to do this when using batch updates to ensure that either all of the updates are committed, or none of them are. If auto commit mode is left enabled and one or more statements fail, the successful changes will be committed anyway, which is not usually the desired behavior. Instead, you'll typically want to roll back all of the changes that were made if any of the update statements fail.

Improved Functionality

With JDBC 1.2, the data represented by a ResultSet is read-only and can be accessed only by moving forward through it one row at a time, beginning with the first row. However, JDBC 2.0 provides much greater flexibility, allowing you to set three properties related to how result sets function. Those properties are concurrency, scrolling, and sensitivity to changes made to the underlying data. (These last two properties are referred to collectively as the result set's "type.") These values are specified when you create a State-

ment instance, and all result sets created by the statement will "inherit" those characteristics. For example:

```
Statement stmt = conn.createStatement(
  resultSetType, resultSetConcurrency);
```

The parameter values should correspond to one of the integer constants defined in the ResultSet class: TYPE_FORWARD_ONLY, TYPE_SCROLL_INSENSITIVE, or TYPE_SCROLL_SENSITIVE for the result set type, and CONCUR_READ_ONLY or CONCUR_UPDATABLE for the concurrency value.

Concurrency mode refers to the ability to modify the data returned by a result set. If your application does not need to modify this data, specifying CONCUR_READ_ONLY for the concurrency mode parameter will cause the statement to create result sets that are read-only, just as in JDBC 1.2. On the other hand, specifying CONCUR_UPDATABLE allows your application to make changes to the data in the result set and have those changes stored in the underlying table(s) in the database.

You can insert new rows, delete rows, and change the values stored in the rows using new methods defined in ResultSet. For example, insertRow() inserts a new row at the current cursor position, while deleteRow() deletes the current row from the result set and the database. To change values stored in a row, JDBC 2.0 provides a new set of updateXXX() methods that modify the data in the result set's current row, just as the existing readXXX() methods allow you to retrieve the data. For each "read" method defined in JDBC 1.2, a corresponding "update" method is also defined in 2.0 (see Table 1.) In general, these changes are not reflected automatically in the database, except for deletions. However, after you have finished modifying an existing row or initializing a newly created one, you can call updateRow() to store your changes.

Data type	Read method (JDBC 1.2 & 2.0)	Update method (JDBC 2.0 only)
Boolean	boolean getBoolean(int col)	void updateBoolean(int col, boolean value)
Float	float getFloat(int col)	void updateFloat(int col, float value)
Int	int getInt(int col)	void updateInt(int col, int value)
Long	long getLong(int col)	void updateLong(int col, long value)
Object	Object getObject(int col)	void updateObject(int col, Object value)
String	String getString(int col)	void updateString(int col, String value)

Table 1 Reading and Writing with ResultSets This list shows some of the read/get methods available for obtaining row data and associated update methods introduced in JDBC 2.0 for use with updatable result sets. Each of these methods is overloaded and has a counterpart that allows you to specify the column's name instead of its index (not shown).

As with prefetching behavior, support for concurrency modes varies from one JDBC driver to the next. To ensure that your driver supports a given mode, use the supportsResultSetConcurrency() method in the DatabaseMetaData class. For more information on using metadata in JDBC, see "Enhancing Database Code with Metadata" in the June 1999 issue of *Java Pro*.

Result Set Types

A result set that is "scrollable" allows you to move the cursor to any row and both forward and backward through its data, instead of just moving forward as was the case in JDBC 1.2. The benefit of this strategy is clear when your application needs to display a huge amount of data. Organizations commonly have database tables with millions of records in them. If the application were to try to load all of the records into memory at once, the user's machine would very likely run out of memory before it could do so. A potential solution to this problem is to display only a portion of the table's records at a time and allow the user to move forward and backward through them. You've probably seen an example of this behavior already, because most Internet search engines use it when you perform a search that returns too many matches to display at one time.

You now have a variety of methods available for positioning a result set's cursor

However, this approach isn't feasible with JDBC 1.2, which allows you only to move forward through the result set. Once you've moved to (for example) record number one million, trying to get back to the previous record requires you to reissue the SELECT and call next() 999,999 times. Obviously, performance would suffer under this approach, and caching the rows already displayed would lead to the original problem of running out of memory. In JDBC 2.0, however, this "scrolling" design can be made to work, because in contrast to the simple next() method provided in JDBC 1.2, you now have a variety of methods available for positioning a result set's cursor (see Table 2).

Method	Description
Absolute(int row)	Positions the cursor at the specified row (the first row in the result set is 1, the second row 2, and so on). If a negative value is specified, then the cursor is positioned at an offset relative to the end of the result set instead of the beginning.
AfterLast()	Positions the cursor past the end of the result set (after the last row).
BeforeFirst()	Positions the cursor at the beginning of the result set (before the first row). This is the same location that the cursor is initially in when a result set is created.
First()	Positions the cursor at the first row.
Last()	Positions the cursor at the last row.
Next()	Moves the cursor forward one row. This is the only method available for cursor navigation with JDBC 1.2-style ("forward only") result sets.
Previous()	Moves the cursor to the previous row in the result set.
Relative(int rows)	Moves the cursor either forward or backward the specified number of rows. If the value specified is positive, the cursor is moved forward by that amount. Otherwise, it moves backward the indicated number of rows.

Table 2 Cursor Navigation New cursor navigation methods added in JDBC 2.0 are available only when working with scrollable result sets. For nonscrollable or "forward-only" result sets, using the next() method is the only way to reposition the cursor.

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Resources

The JDBC 1.2 Specification
http://java.sun.com/products/jdk/1.3/docs/guide/jdbc/spec/jdbc-spec.frame.html

The JDBC 2.0 Specification Update
http://java.sun.com/products/jdk/1.3/docs/guide/jdbc/spec2/jdbc2.0.frame.html

JDBC Drivers List
http://java.sun.com/products/jdbc/drivers.html

Finally, the third property that can be specified for result sets is their sensitivity to changes made to the data in the database while the result set is open. Those changes can be made either by an updateable result set itself (referred to as the result set's "own" changes) or by a different result set or statement (changes by "others"). The distinction between "own" and "others" is important, because JDBC 2.0 allows you to specify whether changes by "others" should be made visible to an open result set. JDBC 2.0 does not, however, allow you to specify whether a result set can see its "own" changes. This sensitivity to changes made by others and the scrollable property are specified together as one of these result set types:

- TYPE_FORWARD_ONLY: This represents a JDBC 1.2-type result set. Only forward movement through the rows in the result set is allowed, and changes made to the underlying data by "others" may or may not be visible, depending on the transaction isolation level and how the database handles the processing of the result set.
- TYPE_SCROLL_INSENSITIVE: Specifying this value indicates that the result set should be scrollable and that changes made to the data in the database by "others" while the result set is open should not be visible through that result set. In other words, the result set represents an unchanging ("static") view of its data and is insensitive to changes made to the underlying data in the database.
- TYPE_SCROLL_SENSITIVE: This specifies that the result set should be scrollable and that it may reflect (is sensitive to) changes made by "others" to the underlying data in the database after it has been opened. That is, the result set should display what is currently stored in the database, including changes made to the data after the result set was opened.

Not all drivers can support each of these types, and DatabaseMetaData provides a way to determine which ones are supported through its supportsResultSetType() method. However, even if a given result set type is supported, the driver may not fully support the expected behavior. For example, if you select a TYPE_SCROLL_SENSITIVE result set, the result set might be sensitive to inserts and deletions, but not updates. To determine what changes are detectable in a sensitive result set, use othersUpdatesAreVisible(), othersInsertsAreVisible(), and othersDeletesAreVisible().

The result set's type affects only sensitivity to changes made by others, and you cannot specify whether or not a modifiable result set is sensitive to its own changes. This behavior varies from one JDBC driver to the next, but the ownUpdatesAreVisible(), ownInsertsAreVisible(), and ownDeletesAreVisible() methods in DatabaseMetaData are provided so that you can determine what behavior to expect from the driver.

Enhanced Object Persistence

New Java-aware database management systems can create stored procedures written in Java (instead of proprietary vendor languages) and even enable you to create user-defined types (UDTs) that correspond to Java classes. You can then create tables with columns that allow you to store instances of the class associated with that column's UDT. With JDBC 2.0, you can obtain a list of the UDTs by using the getUDTs() method in DatabaseMetaData. This returns information on the types, including the name of each one and its corresponding class.

To store and retrieve instances of a class associated with a UDT, use the same writeObject() and readObject() methods that have been available since JDBC 1.2. For example, to write an instance of an Address object that has an associated UDT in the database, you might code something like this:

```
Address addr = new Address();
int custnum = 123;
.
.
.
PreparedStatement ps =
  conn.prepareStatement("UPDATE CUSTINFO
  SET CUSTADDR = ? WHERE CUSTNUM =
  " + custnum);
ps.setObject(1, addr);
```

Similarly, to read an instance of this class from the same row and column:

```
Address addr;
Statement stmt = conn.createStatement();
ResultSet rset = stmt.executeQuery(
   "SELECT * FROM CUSTINFO WHERE
  CUSTNUM = " + custnum);
  if (rset.next()) {
  addr = (Address)rset.getObject(
  "CUSTADDR");
}  //  if (rset.next())
```

When reading and writing object instances, they may be stored using Java's object serialization protocol, but the database vendor can choose to store the instances using some other proprietary persistence mechanism.

If you're convinced of the benefits of using JDBC 2.0 but don't know where to find a driver that supports it, Sun's Web site contains a comprehensive list of vendors, the types of drivers they provide, and the databases they support (see resource listing). Far more drivers still support 1.2, but that is changing quickly.

Incidentally, if it seems like you've read a lot of caveats here about drivers supporting particular features of 2.0, that's because you have. A driver can claim to be 2.0-compliant but still not support the features your application needs. However, over time, most drivers probably will support most or all of these features. In the meantime, make sure that the driver you plan to use supports the features you need by contacting the vendor or, if possible, testing it yourself.

JDBC 2.0 provides a simple way to send updates across the network

In the next installment of this series, we'll look at some of the new data types that are part of the SQL3 standard, and see how they're supported in JDBC 2.0. In the third and final article, we'll see what new features are available as standard extensions and how you can use them. Hopefully you've already seen some things that will be valuable to you in writing database applications, but believe it or not, this is just the beginning. ■

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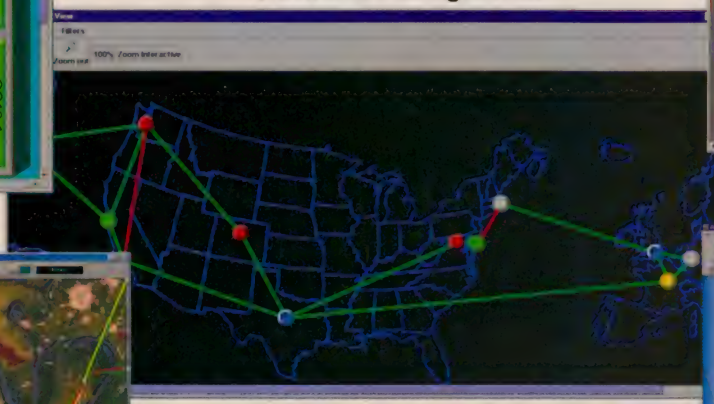

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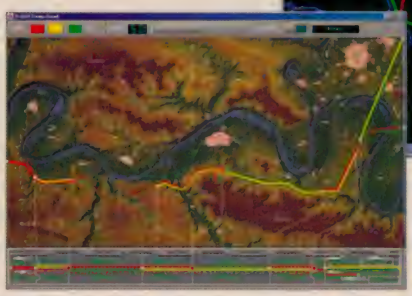

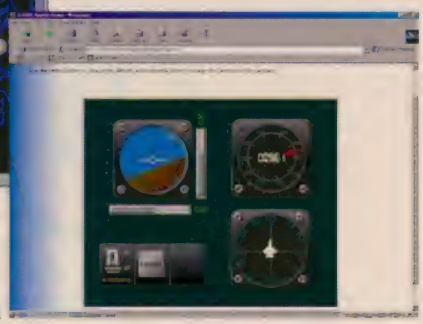

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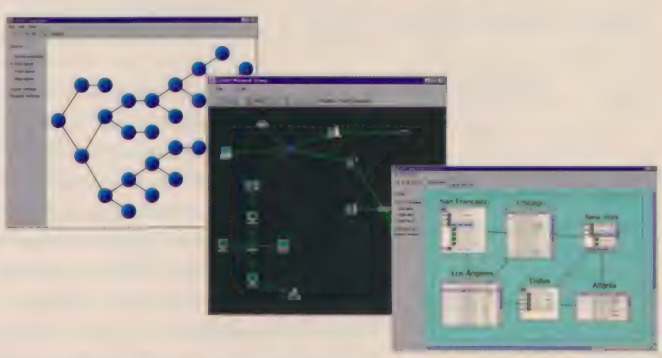

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Java to COM+: Making Cross-Platform Accessibility Work

Building reusable components that will be accessible from multiple platforms and environments isn't easy, but the right tools and some planning will help

by Bill Block and Jerry Brunning

Building a true enterprise system means connecting multiple operational departments *and* multiple computing platforms. Even applications designed to run standalone on one particular platform or operating system eventually may need to be accessible from, or provide services to, an otherwise incompatible platform. One department may use Java to deploy Web-based applications, while another department uses Visual Basic and COM+ to develop Windows applications. What happens when the Java team wants to use a piece of business functionality that the Visual Basic group developed?

To illustrate some of the issues facing developers building cross-platform accessible applications, we'll examine usage scenarios where cross-platform accessibility is required. Specifically, we'll show an in-depth example of one technique for getting a pure Java application to talk to a set of COM+ components running under Microsoft Component Service (formerly Microsoft Transaction Server).

Bill Block is a consultant with Clarity Consulting Inc., a Chicago-based firm specializing in the development of enterprise distributed systems. Bill manages Clarity's Distributed Computing Practice Area and has been involved with the design, development, and implementation of large client/server solutions. You can reach him at bblock@claritycon.com or visit Clarity's Web site at www.claritycon.com.
Jerry Brunning is also a consultant with Clarity Consulting. He wrote the white paper called "Building Year 2000–Compliant Applications with Visual Studio 6.0 and Microsoft Windows DNA" and speaks on Microsoft component technologies. You can reach him at jbrunning@claritycon.com.

Accessibility: Tougher than it Looks

Building applications that share information with each other is no easy task—especially when the applications in question were not built at the same time, or even by the same group in the company. Difficulties are almost guaranteed to arise when your application needs some services or functionality provided by an existing application.

Applications that were designed without the ability to share information with other applications must usually undergo a lot of rework. In some cases, the costs to retrofit an existing application can be significant, even approaching that of a rewrite.

The development tools you use can have a big effect on your ability to write multiplatform accessible applications, so you want to make the right decision. Just deciding on a standard set of development tools is a challenge for even a medium-sized IT department. While most corporate IT departments attempt to standardize on one tool or suite of tools for development, the fact is that many groups will use a variety of tools. Outside circumstances might require a particular tool, regardless of the corporate standard. Some factors that influence this decision include:

Application deployment options Is this a PC-based client/server application? Is it a Web-based transactional system? Is the application a set of COM+ middle-tier components that have no user interface at all?

The target OS platform Do you need to support clients running Windows 95? Do you require a specific service pack for your Windows NT clients?

The nature of the application Is a rich, capable user interface a requirement? Does it need to be multithreaded?

Legacy issues Do you need to interface with existing legacy systems?

Personnel requirements What is the expertise of the development staff? Do you need to hire outside contractors?

Production stage Is this a new application or the next revision of an application already in production?

With so many factors to consider, many developers find that limiting themselves to one set of programming tools is overly restrictive and sometimes even detrimental to their best efforts. Instead, development teams choose from a smorgasbord of tools, with broad, informal guidelines as to when to use a particular product. Too often the tool that

gets chosen for the project is the one that the developers have the most experience using, while other factors take a back seat. All this has the side effect of creating applications that don't communicate well.

What Developers Face

The upshot: Developers are left to sort out the complexities that drive businesses into multiplatform environments. Still, this is nothing new. We have always faced problems getting heterogeneous applications to talk to each other. Even in the best cases the scope of this problem is huge, from native messaging protocols to incompatible operating systems to desktop applications that need to exchange data. Even allowing your users the freedom to choose their own Web browser can have a major effect on your implementation plans. Should you abandon ActiveX controls on your intranet in favor of browser independence? Will your Java solution run under all of the major VMs? Throw into the mix backward compatibility, software distribution, and year 2000 compliance, and you can see how complex this issue becomes.

The complexity becomes more pronounced when you consider the design of a distributed architecture. With a significant piece of the development effort going toward building reusable business components shared by the enterprise, cross-platform accessibility becomes even more essential. Developers run into the inherent limitation of today's prevalent distributed architectures: they're somewhat proprietary. For example, DCOM works well with Microsoft technologies, but not with others, while CORBA and Enterprise Java Beans (EJB) are beginning to compete.

In an ideal environment, we would build systems with a keen understanding of today's business and tomorrow's direction, including an understanding of the need to exchange data with other applications. Sometimes, however, you get there too late. There still will be times when you need to link two or more applications that were built without anticipating this requirement. Developers have coped with this problem for years. So how have we adapted to this need that's been there all along, but seems to get only more complex? After all, applications are still built, deployed, and integrated, and—in some cases—still communicate with each other. We've continued to move forward, but sometimes past solutions have been mere workarounds, which we fell back on when we couldn't find a better solution, or because a better solution was too expensive.

In most cases, the easiest method for facing the need to have two applications communicate is to limit the functionality on the client—basically, to ignore the need. So, for example, when users employ multiple systems to perform different tasks, we may force them to log in to each system separately, instead of figuring out how to pass user credential and profile information from a legacy mainframe application to our client/server piece. This action presents only a minor nuisance to the user, but fixing it could be a big effort for a developer. However, dismissing the problem is not always so easy. In some situations, most of the company's business may depend on two enterprise applications being able to communicate.

IT departments often try to duplicate functionality in two applications rather than share it between them. For example, we may have a set of COM+ components enforcing our business rules. If we wanted to build a pure Java applet for one of our customers, the applet could not easily access our business components. Instead, we would have to duplicate the code in Java. Not only does this create a duplicate code base to maintain and deploy, but it also increases the chance that our order rules will not be applied correctly (maybe through a bug in the Java code or an oversight while translating the business rules). Duplicate functionality is a common real-world problem. In fact, companies often weigh the cost of reworking applications to share data against the cost of rewriting one or more of the applications.

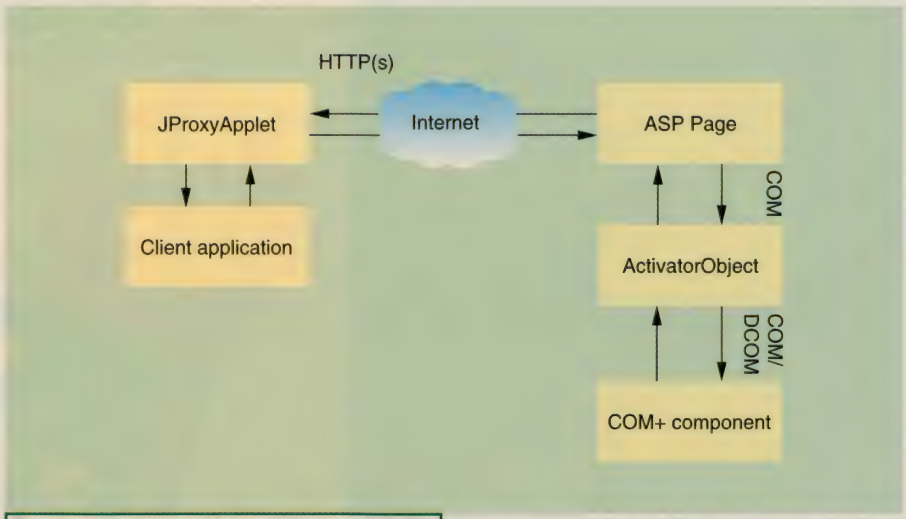

Figure 1 Anatomy of Cross-Platform COM+ An overview of the architecture. An application on Windows connects to a non-Windows platform by way of COM+-to-Java communication over the Internet. The JProxyApplet communicates with the COM component using XML over a secure HTTP connection.

Planning Better Solutions

Today, you have several options for performing distributed communication. First, DCOM rules the Microsoft world. DCOM is easy to use in client/server applications where both the client and server run a Microsoft operating system, but it is more difficult or impossible to use when trying to achieve interoperability between multiple environments. CORBA and Enterprise JavaBeans have been gaining support in non-Microsoft development groups, but, like DCOM, CORBA and EJB are often tied to proprietary hardware or software systems.

The cost of retrofitting an existing application can approach that of a rewrite

Another approach is IP messaging (for example, open a socket to port 9981 on server 127.0.0.1). This approach lets the client and server portions of your application communicate directly, but problems can still arise. For example, when an application needs to communicate through a proxy server or a firewall, it must now open ports on a firewall. Many system administrators frown on opening additional ports to the Internet. Even more problematic with the direct IP approach: Applications using pure socket connections are tied to a specific IP, so scalability quickly becomes an issue.

Of the many methods for communicating in a distributed environment, most are proprietary or require too much overhead to be cost-effective. Using these methods in a cross-platform environment, or even a cross-development envi-

Listing 1 Sending Messages This is an example of an XML message sent from a JProxyApplet to an ASP page.

```
  <methodcall>
    <progid>GeographyLibrary.PhoneBookClass</progid>
      <method>BrowseByNameAndAreaCode</method>
      <parameters>
        <parameter>
          <datatype>String</datatype>
          <value>John Smith</value>
      </parameter>
      <parameter>
          <datatype>Integer</datatype>
          <value>312</value>
        </parameter>
      </parameters>
      <returntype>Recordset</returntype>
</methodcall>
:

XML message returned from ASP page to JProxyApplet

  <methodreturn>
    <datatype>String</datatype>
    <value>312-555-1212</value>
<methodreturn>
```

TechTIP

Hex Your Bytes to Display

You may find yourself in a situation were you want to convert an array of bytes "byte []" into a hex string to display. The following method does exactly that.

```
String byteArrayToHexString(byte in[])
{
byte b = 0x00;
int i = 0;
if (in == null || in.length &lt;= 0)
return null;
String hexNums[] = {"0", "1", "2", "3", "4", "5", "6", "7", "8", "9", "A", "B",
  "C", "D", "E", "F"};
StringBuffer out = new StringBuffer(in.length * 2);

while (i &lt; in.length)
{
b = (byte) (in[i] & 0xF0); // Strip off high nibble
b = (byte) (b &gt;&gt;&gt; 4); // shift the bits down
b = (byte) (b & 0x0F); // must do this if high order bit is on!
out.append(hexNums[ (int) b]); // convert the nibble to a String Character
b = (byte) (in[i] & 0x0F); // Strip off low nibble
out.append(hexNums[ (int) b]); // convert the nibble to a String Character
i++;
}
return new String(out);
}
```

Say you have:

```
byte byteArray[] = {(byte)0xf1, (byte)0x0d, (byte)0x3c, (byte)0x44};
```

which is equivalent to "F10C3D22," you can display it as in:

```
String s = byteArrayToHexString(b);
System.out.println(byteArray)
```

Behrouz Fallahi

ronment, can get tricky. Engineering communication between DCOM and Java, for example, is messy—but it isn't impossible.

Integrating applications or platforms by purchasing a third-party tool to assist in development and deployment can work, but it often has high costs. Developers must learn how to integrate the new product into their applications, and system administrators must learn how to support new services. Moreover, third-party tools can limit the way applications communicate, because developers have little control over the means by which interoperability is achieved. Instead, that control is left up to the third-party tool designer.

What else can be done? While building your own cross-platform communication mechanism may sound like a huge task, it really isn't if you leverage existing systems and protocols.

Solving a Java Problem

We ran into a problem when one of our clients, who had been developing in 100% Pure Java, wanted to communicate with our COM+ components. Now we needed a way for a Java application to make what was essentially a DCOM call to our DLLs running under Microsoft Transaction Server.

The architecture we came up with used existing resources and knowledge to build a simple but comprehensive solution to our problem. The architecture consists of three main parts: a Java proxy/listener (for simplicity we'll refer to this piece as JProxyApplet), an ASP page hosted on our IIS server, and a business component used to "activate" our COM+ components (we'll refer to this object as the ActivatorObject). In a typical scenario (see Figure 1), the Java client sends a method request to the JProxyApplet component. The JProxyApplet next forwards that request to an ASP page, using query string parameters. The ASP page, in turn, calls the activator business component, which then calls the COM+ components and finally returns results in the response of the ASP page.

The most important step is creating a set of well-defined message layouts

The first, and arguably the most important, step in building this architecture is to create a set of well-defined message layouts. The messages sent between systems must be clear, yet must contain all the information necessary to process the requests. Extensible Markup Language (XML) offers a standard, well-supported

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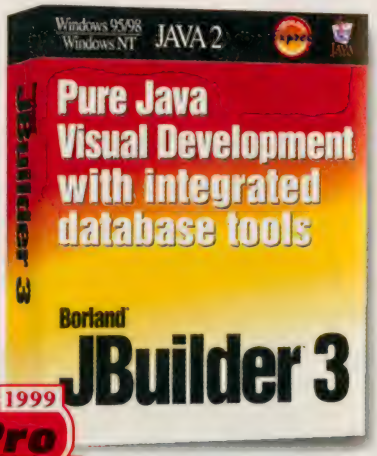

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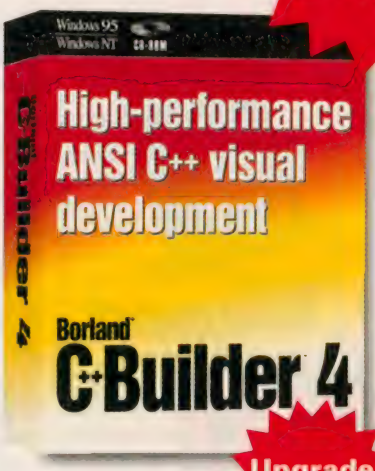

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VersionStamper provides a complete distribution solution. Determine the component dependencies of any project, detect conflicts based on embedded or remote file lists, and get automatic notification or software updates. VersionStamper 6 adds new lightweight ATL based components, controls and emergency rescue program. A new dependency wizard determines the components used by an application and creates scripts for verification and remote updating.

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Pub: $975.00
DevX Price: $959

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Format: CD ROM
Pub: $765
DevX Price: $749

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Format: CD ROM
Pub: $1,995
DevX Price: $1,929

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Pub: $2,470
DevX Price: $2,399

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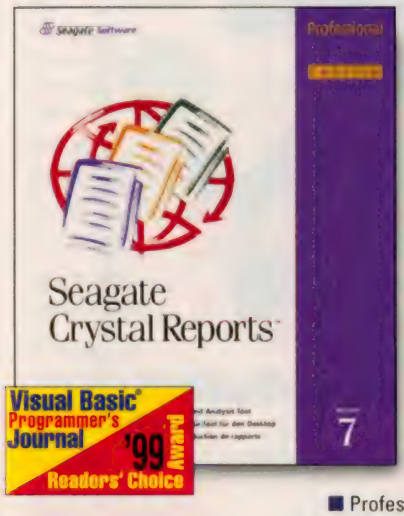

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  Pub: $1,619
  DevX Price: $1,499
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  Format: CD ROM
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Also see page 4

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  Format: CD ROM
  Pub: $279
  DevX Price: $249
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  Pub: $999
  DevX Price: $839
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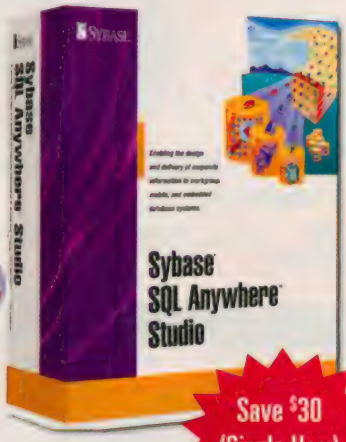

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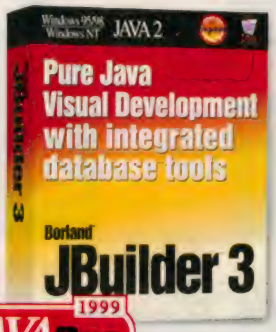

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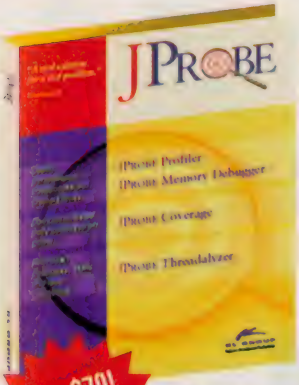

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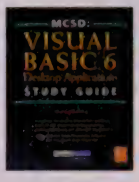

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way to implement this message structure. XML was originally designed to be the data format for exchanging structured data over the Web. For that reason, we chose to implement our messages in an XML format. A sample message from the JProxyApplet to the ASP page and a message from the ASP page to the JProxyApplet would look like the samples in Listing 1.

The next step was to define the lowest point of communication on both the client and the server. Specifically, on the client we built the JProxyApplet, and on the server we developed the ASP page. To start with the server piece, the ASP page residing on the IIS server, we chose to have only one input: the message itself. Therefore, incoming requests are made to the ASP page with the following format:

```
http://mycompany.com/services/
  components.asp?message=<methodcall>
```

The parameter "message" contains the entire method call request in the formatted XML that we'd already defined. From within the ASP page, we then call the business object that will parse the XML and perform the method calls.

On the client, we designed the JProxyApplet (see Listing 2), a small, invisible applet that listens for messages from client applications and then forwards those messages on to the ASP page residing on an IIS server. First, the JProxyApplet asks the virtual machine for both connect and listen privileges by calling the Java Security API. The security calls will be slightly different depending under which browser the applet runs. The applet can detect which browser is hosting the applet and then set the necessary privileges.

Next, the applet creates a ServerSocket object, which will listen on a predefined port on the local machine. After defining the ServerSocket, a socket can be initialized to accept all messages on that port. Using the Socket object, along with Java's built-in streaming capabilities, we can send and receive messages. Once we have set up the socket, we wait indefinitely for data from the client application.

Whenever a message arrives on the socket, within the JProxyApplet, we create a new URL object and POST the message to the ASP page. The results of the POST are then sent over the socket's output stream and back to the caller—in this case, the Java client. Since Java has strong networking capabilities built into the VM, all the communication can be handled in fewer than 100 lines of Java code.

The final piece of the architecture is the ActivatorObject, the business object that activates COM+ components (see Listing 3). The ActivatorObject resides on the same server as the ASP page. The ASP page calls the ActivatorObject, passing in the XML message received in the query string parameter. From there, the ActivatorObject parses the XML. We used the Microsoft XML parser, since we were creating the ActivatorObject in Visual Basic, and Microsoft's XML DLL made it easy to manage and manipulate our data. Once the XML message has been parsed, we use the CallByName() method in VB to activate the COM+ object and pass in the necessary parameters. Any return values from the COM+ method calls are returned as XML strings. The ASP page then takes the XML return string and passes it back to the JProxyApplet by issuing a Response.Write(). It should be noted that the only text going back across the wire to the JProxyApplet is the XML message itself. In other words, there are no HTTP headers or tags returned in the contents of the response.

Since the XML messages are defined rather generically, we can pass a wide variety of data types to and from our COM+ components, including strings, numerics, booleans, and even ADO Recordsets. In the special case of ADO Recordsets, we persisted the Recordset to XML using the ADO 2.1 Save() method (with the next version of ADO, Recordsets can be converted directly from an object to XML, which would eliminate this step). In both the JProxyApplet

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Listing 2 Walking through the Code The JProxyApplet is a small, invisible applet that listens for messages from client applications and then forwards those messages on to the ASP page residing on an IIS server.

```
Step 1: Enable connect and listen privileges (Netscape only)
PrivilegeManager PM =
  PrivilegeManager.getPrivilegeManager();
PM.enablePrivilege("UniversalConnect");
PM.enablePrivilege("UniversalListen");

Step 2: Create and open a socket
server = new ServerSocket(9801);
socket = server.accept();

Step 3: Setup the input and output streams
is = socket.getInputStream();
os = socket.getOutputStream();

Step 4: Wait for incoming data
while (is.available() == 0)
{ /* wait */ }


Step 5: POST the data to the ASP page
String strURL = new String(
  "http/mycompany.com/services/components.asp?message=" +
  strMessage);
URL url = new URL(strURL);

Step 6: Wait for return data
BufferedReader in = new BufferedReader(
  new InputStreamReader(url.openStream()));
while ((current_line = in.readLine()) != null)
{
  output = output + current_line;
}
strResponse = output.toString();


Step 7: Send the data over the socket and back to the client
BufferedWriter outputBuffer = new BufferedWriter(
  new OutputStreamWriter(os));
outputBuffer.write(strResponse);
outputBuffer.flush();
```

Listing 3 ActivatorObject The ActivatorObject is the business object that activates COM+ components.

```
Step 1: Load the XML string into the Microsoft XML parser
Dim objXMLDoc As New MSXML.DOMDocument
Call objXMLDoc.loadXML(XMLString)

Step 2: Parse the contents of the message
Set objNode = objXMLDoc.getElementsByTagName("progid")

Step 3: Call the component's method
Set vntOut = CallByName(objGeneric, strMethod, VbMethod,
  vntParameters)

Step 4: Return the results
PerformMethod = "<returnvalue>" & vntOut & "</returnvalue>"
```

and the ActivatorObject, logging and diagnostic code was added to allow for more complete tracking of messages within the system.

Learning from the Architecture

This architecture presents you with several benefits and some drawbacks. One big benefit: Developers have full control of the underlying workings of the system. For example, changing the message layout to support additional functionality is simple. On a related note, changing the message structure of the communication mechanism will not inherently break either the client or server code. Since a "proxy" piece is used on both the client and server side of the communication, both the client and the server can be shielded from the interface (message structure) change by handling the additional structure elements within the JProxyApplet and ActivatorObject pieces.

This architecture also gives you the benefit of scalability. Since the server is a Web server, implementing a Web farm to increase the number of users the application can support is easy. And if developers build stateless components using COM+ component services, the architecture will continue to support an increasing number of users over time. In addition, COM+ adds load-balancing capabilities, which will lower the amount of redundancy and fail over code that needs to be written for the ActivatorObject, and should ease administration of multiple business components across multiple servers.

An interesting twist to this architecture is security. While integrated NT security will no longer be available for the COM+ components running under this architecture (they will now be activated from an ASP page under the IUSR user account), the architecture will allow for client authentication using client certificates and SSL. In other words, there is a shift in security models from an integrated NT security model to an Internet certificate/SSL model. Similarly, encryption is another benefit of shifting to the certificate/SSL model, since you get encryption "for free" with SSL.

Finally, because the architecture relies heavily on industry-proven protocols such as HTTP, HTTPS, sockets, and SLL, it is likely to be supported over the next decade. While these standards may be modified, they'll still be a part of the distributed application landscape. HTTP and XML are both well-supported, which makes it easy to develop solutions that implement both protocols.

Obviously, the environment will determine what approach you should take for developing cross-platform or cross-development tool applications. The level of interoperability you need and the level of complexity you want to manage will determine which approach works in your environment. If you already have Web servers in place and want to leverage your existing COM+ components from different systems, the approach may work for you. If you want to take advantage of the new features of COM+ without dropping your existing non-Microsoft applications, the architecture offers one way of achieving a high level of cohesion.

This technique is just one way of sharing data between applications. Examine other approaches in light of your needs before making an infrastructure change. Depending on the strictness of your organization's standards, your budget, and third-party software availability, a solution can be implemented. The key is developing or deploying the right tools—tools that do not exceed the budget or sacrifice functionality. And you must try to anticipate the need for interoperability. If you do enough planning, you'll be better prepared to implement a solution that is cost-effective and appropriate for your environment. ■

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Javatecture

How I Started Using JavaServer Pages

I've spent some time recently trying to understand JavaServer Pages (JSP) and why and where you use them. They're a clever technology, although they do result in messy pages of code.

You'll remember that we've discussed Java servlets—a Java technology to replace cgi-bin client-server programming with a more efficient model. Ordinary cgi-bin programs are launched by the Web server when HTML form pages are sent to a particular directory. These cgi-bin programs parse the form information and create a new dynamic HTML response page, which they return to the client. Java servlets improve on this methodology by keeping a servlet engine running, which catches cgi-bin programs and parses them in Java. The servlet then computes the desired response page and returns it to the client in much the same way.

The problem with both of these approaches is that there is no good way to construct complex output HTML pages. Usually, programmers rely on some kind of template pages, which they copy and fill in with data from a particular cgi-bin query. This is one reason why most response pages look simple, and many are downright ugly.

JavaServer Pages are one solution to this problem. A JSP page contains both HTML to create the final output page and Java to fill in the parts that must be computed. It also does the form parsing directly and almost invisibly for you. JavaServer Pages are supported by a class of programs called application servers. Some of these packages add on to existing Web servers; others perform both the Web server and the JSP functions directly. You will find a complete list of products at java.sun.com/products/jsp. You should be careful when ordering these products, because some of them support only back-level versions of JSP (0.91 was popular, but quite different) and the syntax of JSP pages has changed substantially in the final 1.0 release.

JavaServer pages let you interweave Java and HTML—this is both a strength and a weakness

BY JAMES W. COOPER

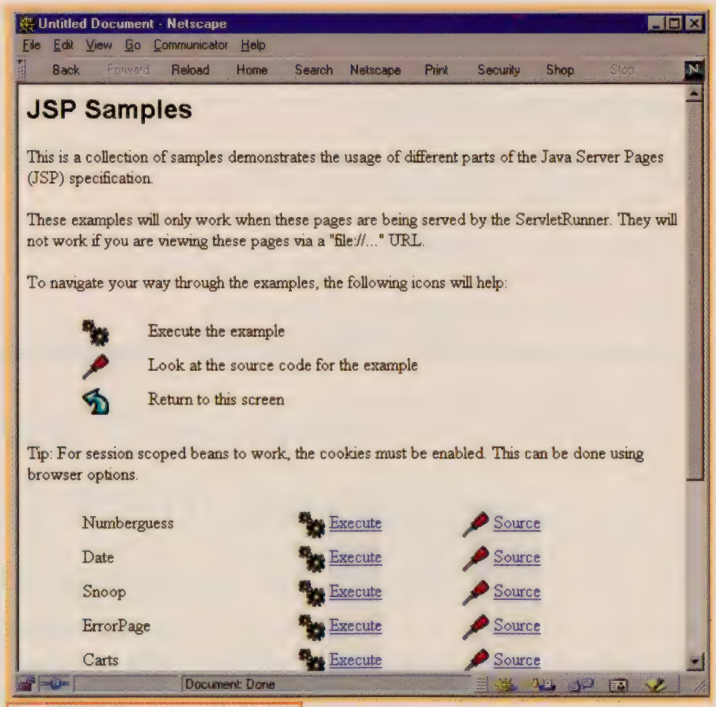
Untitled Document - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop Stop
JSP Samples
This is a collection of samples demonstrates the usage of different parts of the Java Server Pages (JSP) specification.
These examples will only work when these pages are being served by the ServletRunner. They will not work if you are viewing these pages via a "file://..." URL.
To navigate your way through the examples, the following icons will help:
Execute the example
Look at the source code for the example
Return to this screen
Tip: For session scoped beans to work, the cookies must be enabled. This can be done using browser options.
Numberguess Execute Source
Date Execute Source
Snoop Execute Source
ErrorPage Execute Source
Carts Execute Source
Document: Done

Figure 1 JSP Samples Page You can learn a lot from these examples by watching them run and by examining the code.

Installing the JSP Development Kit

You will also find the complete JSP development kit at the Web site under the name JSWDK-1.0. If you download this package and install it, you will have a complete working JSP system where you can develop and test JSP pages as well as servlets and then deploy them to your site. The JSP engine provided in this kit is adequate for small sites, but for larger sites, you need one of the application servers. An application server is a superset of the servlet engine and supports both JSP pages and ordinary servlets.

To try out the servlet engine on Windows NT, go to the JSWDK-1.0 directory and run startserver.bat. On Unix machines, run the startserver shell script that also is provided. I did all my testing on Windows NT 4.0 with Service Pack 5 installed. I wrote my test programs on a laptop that was not connected to any network. I was not able to get the examples to run on the same laptop running Windows-95b (OSR2).

Listing 1 Connecting with Beans Most JavaServer Pages connect with simple JavaBeans that contain and return the contents of the fields on the page. The beans that JSP pages use are invisible server-side beans that have just get() and set() methods. They have no visual properties.

```
package mine;
//A simple Java bean for the Hi demonstration programs
public class JTest {
  private String text; //text stored here

  public JTest() {
    text = null;
  }
  //set text here
  public void setEntryText(String t) {
    text = t;
  }
  //get it back here
  public String getEntryText() {
    return text;
  }
}
```

To see the test programs that come with the JSWDK, start your Web browser and enter the URL http://localhost:8080. This brings up a page describing the available examples and the servlet API. If you click on the JSP Samples link, you will get the page shown in Figure 1. You can learn a lot from these examples, by watching them run and examining the code. However, since JSP pages are still poorly documented, we'll start at the beginning with a simple "Hi" program and work up to some of the concepts they illustrate.

A Hello World JSP Program

A JavaServer Page consists of HTML, JSP directives, and Java code. The JSP engine compiles this code and caches it when you first access the page. This makes further accesses to the page much faster. The JSP page is a server-side concept: the code that is sent back to the client is pure HTML generated by the code on that page. This makes the client requirements much less demanding than those that require particular levels of Java support.

Our first simple program, hi.jsp, consists of a simple form, some output, and communication with a back-end JavaBean. All JavaServer Pages must start even before the <html> tag with declarations defining that it is a JSP and the JavaBean it will communicate with:

```
<%@ page language="java" import="mine.JTest" %>
```

or

```
<jsp:useBean id="mine" scope =
  "page" class="mine.JTest" />
```

The first line is a jsp directive, describing the language (only Java is supported) and the bean the page will communicate with. The second line is the same jsp directive in an alternate format. You need only one or the other, although both do no harm. Note that the longer form follows the XML custom, terminating the tag with a /> to indicate that nothing more follows that relates to that tag.

JavaServer Pages are a clever technology, although they do result in messy pages of code

JavaBeans and the JSP

Most JavaServer Pages connect with simple JavaBeans that contain and return the contents of the fields on the page. The beans

TechTIP

Center Your Frames and Dialogs

You can find many tips on how to center a window within the screen, but how about centering a window in its parent container? The following code shows you how to do that. Say you have a JFrame (or Frame), and you launch a JDialog (or Dialog) like this:

```
JDialog jd = new JDialog(this);
//you have to pass the this pointer of Frame to establish
//parent-child (or owner-owned) relationship
jd.setVisible(true);
```

In the code for JDialog, you can use the following to center the dialog with respect to its owner frame:

```
public void centerInParent ()
{
  int x;
  int y;
  Container parent = this.getParent();
  Point topLeft = parent.getLocationOnScreen();
  Dimension parentSize = parent.getSize();
  Dimension ownSize = this.getSize();
  if (parentSize.width &lt; ownSize.width)
    {x = ((parentSize.width - ownSize.width)/2) +
      topLeft.x;}
  else
    {x = topLeft.x;}
  if (parentSize.height &lt; ownSize.height)
    {y = ((parentSize.height - ownSize.height)/2) +
      topLeft.y;}
  else
    {y = topLeft.y;}
  this.setLocation (x, y);
  this.requestFocus();
}
```

For the sake of completeness, the following code centers a Dialog or Frame within the screen:

```
public void centerInScreen()
{
  Dimension dim = this.getToolkit().getScreenSize();
  Rectangle bounds = this.getBounds();
  this.setLocation((dim.width - bounds.width) / 2,
    (dim.height - bounds.height) / 2);
  this.requestFocus();
}
```

Behrouz Fallah

Figure 2 Unsatisfactory Results The simple hi1.jsp program (a) before and (b) after entering a name and pressing submit. This is not satisfactory, because we display "Hello there: null" before any name has been submitted.

used by JSP are invisible server-side beans that have just get() and set() methods. They have no visual properties. For example, you might have a <form> section on your page and inside it a text entry field.

```
<input type="text" name="entryText" size="25">
```

The associated JavaBean then has get() and set() methods for this field (see Listing 1). Note that the case is odd but required. The name of the field must start in lower case, but the get() and set() methods convert it to upper case. When you begin using this bean on a JSP, you must initialize all of its properties to access them.

```
<jsp:setProperty name="mine" property="*"/>
```

This line initializes all the bean's properties at once. This statement is required, or your bean properties won't work.

Communicating with the JavaBean

The complete form section of our JavaServer Page looks like this:

```
<form method="post">
<input type="text" name=
 "entryText" size="25">
<br>
<input type="submit" value="submit">
</form>
```

Note that although a post() method is specified, no *action* is specified that tells the page where to send the form. Instead, submit just sends all the form data to the JavaBean, executing the set() method for each form field. In this case, the JSP calls the bean's setEntryText() method with the string from the entry field as its argument. Thus, following the submit, the bean contains all the data in the form's entry fields.

You can access that data using the get() methods and can print it out on the Web page using JSP statements:

```
<%
out.println(mine.getEntryText());
%>
```

Note that you can embed real Java statements on a JavaServer Page as long as they are enclosed in the <% and %>. You can also use a shorter form, where the equals sign replaces the "out.println" method call:

```
<%= mine.getEntryText() %>
```

This form is not a complete Java statement and does not need a terminating semicolon. Since it is so compact, you see it frequently.

Listing 2 A Complete Page This program initializes the *mine* bean, uses the submit button to load it, and prints out the result.

```
<jsp:useBean id="mine" scope =
 "page" class="mine.JTest" />
<jsp:setProperty name=
 "mine" property="*"/>

<html>
<head><title>Hi</title></head>
<body>

<form method="post">
<input type="text" name=
 "entryText" size="25">
<br>
<input type="submit" value="submit">
</form>

Hello there: <%= mine.getEntryText() %>

</body>
</html>
```

Listing 3 Our Hello World Program This example tests for whether the name is non-null before displaying it.

```
<jsp:useBean id="mine" scope =
 "page" class="mine.JTest" />
<jsp:setProperty name=
 "mine" property="*"/>

<html>
<head><title>Hi</title></head>
<body>

<form method="post">
<input type="text" name=
 "entryText" size="25">
<br>
<input type="submit" value="submit">
</form>

<% if (mine.getEntryText() != null) { %>
 Hello there:
 <%= mine.getEntryText() %>
<% } %>

</body>
</html>
```

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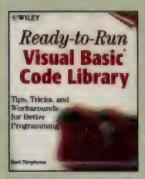
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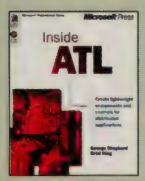
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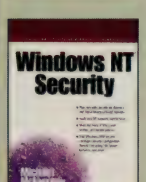
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Listing 4 Diminishing Clutter In this example, the test for printing Hello there and a name are moved to another file, which keeps the HTML and server-side logic together, but logically separated. This approach gives the Web designer control over the base jsp file and the server programmer control over the output in the myResponse.jsp.

```
<jsp:setProperty name="mine" property="*"/>

<html>
<head><title>Hi</title></head>
<body>

<form method="post">
<input type="text" name="entryText" size="25">
<br>
<input type="submit" value="submit">
</form>

<%@ include file="myResponse.jsp" %>

</body>
</html>
```

Our First Complete JavaServer Page

Combining these fragments, we have a complete page (see Listing 2). This program initializes the *mine* bean and uses the submit button to load it. Then it prints out the result.

The displays in Figure 2 are not satisfactory, because we display "Hello there: null" before any name has been submitted. It would be better to display this only when there is real data. The second JSP example accomplishes this by testing for whether the name is non-null before displaying it (see Listing 3).

In this example, we do not see any "Hello there" text or null name displayed. Note how we can interweave Java and HTML in the same page to make decisions about what to display. This feature is both the greatest strength and weakness of JSP pages. You can write Java code to display data, but interweaving it makes the page look unstructured and confusing.

Now the purpose of JSP is to keep HTML and server-side logic together, but logically separated to diminish clutter. The final example, hi3.jsp (see Listing 4), just moves the test for printing Hello there and a name to another file, which is referred to using an include statement.

This gives the Web designer control over the base jsp file and the server programmer control over the output in the myResponse.jsp, which is much the same code as in hi2.jsp:

```
<% if (mine.getEntryText() != null)
{ %>
 Hello there:
 <%= mine.getEntryText() %>
<% } %>
```

Where to Put All These Classes?

If you install the JavaServer Page JDK as we described, you will have a tree that contains

```
Jswdk-1.0\examples\jsp
```

along with many little directories underneath for each of the provided examples. Unzip the jsp code into a new "hi" folder at this level.

The JavaBean goes into the hierarchy:

```
Jswdk-1.0\examples\Web-inf\jsp\beans
```

Create a folder called "mine" and unzip the bean into it.

Automated Tools

You can see the power of JSP compared to other approaches. However, you can also see the clutter and confusion they can generate. The newest versions of several of the Java IDEs, including Borland's JBuilder and IBM's Visual Age for Java, contain methods for building JSP a little more automatically. These newer generations of IDEs should help developers reduce the clutter and unleash the powerful potential of JavaServer Pages.

James W. Cooper is a computer science researcher and the author of 13 books. His latest, on Java design patterns for Addison Wesley Longman, is due out this month.

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Unit Testing Prevents Errors

by Adam Kolawa

In previous columns, we have focused on coding standards. This month, we will introduce unit testing as a method of error prevention. To understand the importance of unit testing, we must first take a look at the state of testing in software development today.

Developers today face increasing deadline pressure as they write code in a competitive software market. They often write code quickly without regard for quality, and then send it off to another department to have it tested. However, the best person to test a segment of code is the developer who wrote it. He or she understands the code better than anyone else and is most capable of finding the weaknesses in the code.

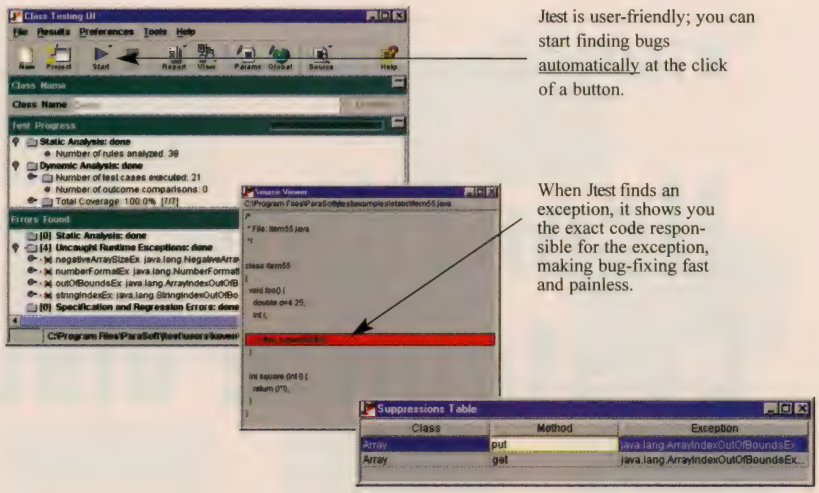
As developers test code, they should not just be trying to finish quickly and go home early. Rather, they should be trying to break the code in any way possible. Successful testing is not merely any testing that finds no errors; it is testing that flushes out errors. Instead of mentally rewarding yourself for code that appears clean, you should reward yourself for finding bugs. Just because code compiles cleanly does not mean that the code is ready to ship to customers. Adopt a new, more critical outlook on your code, and you will see dividends in the cleanliness of that code.

Once you have adopted this new outlook towards testing, you need to find an effective method of testing. One of the most effective methods is unit testing.

Often, developers hear about unit testing and think the term refers to module testing. But the term "unit testing" refers to an even lower level of testing--a testing that occurs at the class or object level. Class-level testing is extremely important to the well-being of any application, but few developers perform class testing. Most developers think of class testing as a sort of "golden rule"--a form of testing that they would perform in an ideal world if they had time. However, because of the labor and mechanics involved, they avoid class testing and believe that it is not possible to perform on large applications.

In upcoming columns, we hope to illustrate that although unit testing at the class level involves some extra work when it is done by hand, the technique is certainly feasible and worthwhile. Furthermore, technology has evolved to the point that developers can now choose from a number of powerful tools that make unit testing as easy as breathing.

Dr. Adam Kolawa is President and CEO of ParaSoft.
He can be reached at ukola@parasoft.com



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For version 3.0, ParaSoft has added three impressive new testing capabilities to Jtest: black-box testing, regression testing, and static analysis.

Black-box testing, which ensures that each class behaves according to specification, is now a quick and easy process with Jtest. During black-box testing, Jtest automatically provides a set of inputs based on sophisticated analysis and executes the class with the inputs. The user can also provide a set of inputs that will be tested along with the automatically generated inputs. Jtest will then report the outcomes, which the user can verify with one click of the mouse.

Jtest automates regression testing, a process similar to black-box testing. During regression testing, Jtest helps make sure that developers do not re-introduce errors to their code. Jtest remembers outcomes from previous runs and compares outcomes every time the class is tested, reporting an error if an outcome changes. Developers can use Jtest to make sure they are not letting their code regress into previous errors when they make changes.

In addition, you can now enforce Java coding standards automatically with the new static analysis feature of Jtest. Jtest parses the Java source of a class and applies to it a set of rules. Any violations to these rules are reported as errors. Enforcing coding standards at every stage of the development process will lessen the amount of debugging developers must perform later in the development cycle.

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Visual Components

JIconEditor Lets Users Customize Visual Elements

Supporting customizability adds value to graphics applications and IDEs

BY CLAUDE DUGUAY

One of the best ways you can add value to your application is by supporting a high degree of customizability. Swing gives you an immediate edge, with a pluggable look-and-feel model that lets you offer flexibility in only a few lines of code. An interesting enhancement is to allow users to customize visual elements such as icons. Depending on your customers, this may be more than you want to offer, but in some applications, such as integrated development environments or graphic applications, this is a nice feature. This month's visual component is a full-function icon editor.

Figure 1 shows JIconEditor in action. As you can see, we support common tools such as a pencil for single pixel editing; an eye dropper for sampling colors; paint fill, erase, move, and shape drawing tools; and vertical and horizontal flipping and rotation.

We'll use several classes in this component; you can see how they relate to each other in Figure 2. JIconEditor uses three toolbars derived from the ToolPanel class, each of which uses a specific type of button. The PixelEditor is an extension of a PixelView and uses an ImageOps class to delegate image operations. The Action and Draw buttons and toolbars, along with the PixelEditor, make use of some common constants declared in ActionConstants and DrawConstants interfaces for convenience. Not all of these classes can be listed in print, so be sure to check www.java-pro.com to get the full listings.

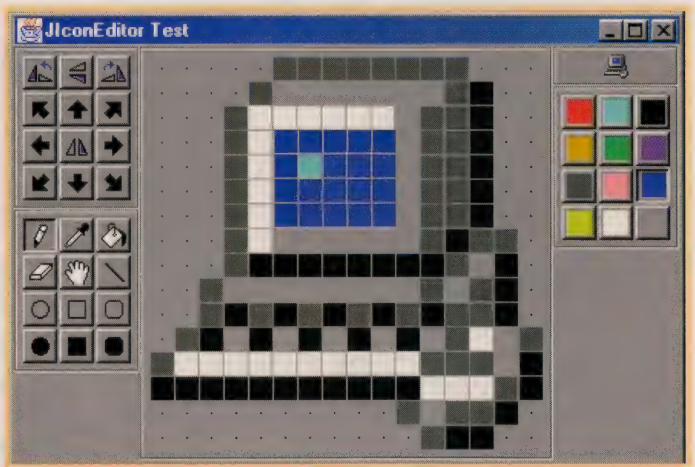

Figure 1 JIconEditor in Action JIconEditor supports familiar tools.

Toolbars

Rather than use dockable JToolbar implementations, I chose to use a base class called ToolPanel, which is primarily a JPanel intended to support action event dispatching. ToolPanel implements addActionListener(), removeActionListener(), and fireActionEvent() methods, which allow us to send notification to listeners whenever something happens. If you want to make these dockable, you can always drop them into a JToolBar without making any sacrifices.

The three toolbars in our implementation are shown in Figure 3: the DrawToolbar is responsible for selecting drawing tools; the ActionToolbar triggers actions like flip or move; and the PaletteToolbar lets you select the active color. (If you read last month's column, you know I was distracted into developing a JPalette component for use in this context. Here I'm intentionally implementing a simplified palette toolbar so that there are no code dependencies between columns. If you download the code from both columns, you can substitute the PaletteToolbar with the JPalette to produce an even more sophisticated icon editor.)

The PaletteToolbar uses a PaletteButton (see Listing 1), which extends JToggleButton so that we can make these members of a ButtonGroup. This allows us to create a mutually exclusive selection group without much effort. The PaletteButton class stores a color, which we make accessible from a getColor() method. We also set up a few parameters like the preferred and maximum size, image positioning, and focus handling (which we effectively disable). The icon is built in the constructor with a BufferedImage, filled with the selected color.

Since we want each of the buttons in the toolbar to be added to the panel, registered with an action listener, and be a member of a ButtonGroup, we'll construct them in advance in an array and iterate through the array, operating on each in the same way. The only other thing our constructor does is set up a GridLayout and a suitable Border.

The PaletteToolbar class (see Listing 2) implements the ActionListener interface and receives notification when a button is pressed. From that, we store the active color and fire an action event of our own to any ActionListener registered with the PaletteToolbar. This is easy, since we're inheriting from the ToolPanel and need only call the fireActionEvent() method. You'll see this pattern repeated in the rest of our toolbars.

The DrawToolbar class implements another set of mutually exclusive buttons. These DrawButton instances determine the drawing context we are in, such as erasing or drawing pixels or shapes. To make it easier to reference resources, we use a DrawConstants interface that lets us include the same constants in other classes. If you've never seen this technique before, it's convenient primarily because you don't have to keep qualifying each constant with the class in which it was declared, since the interface can be included anywhere.

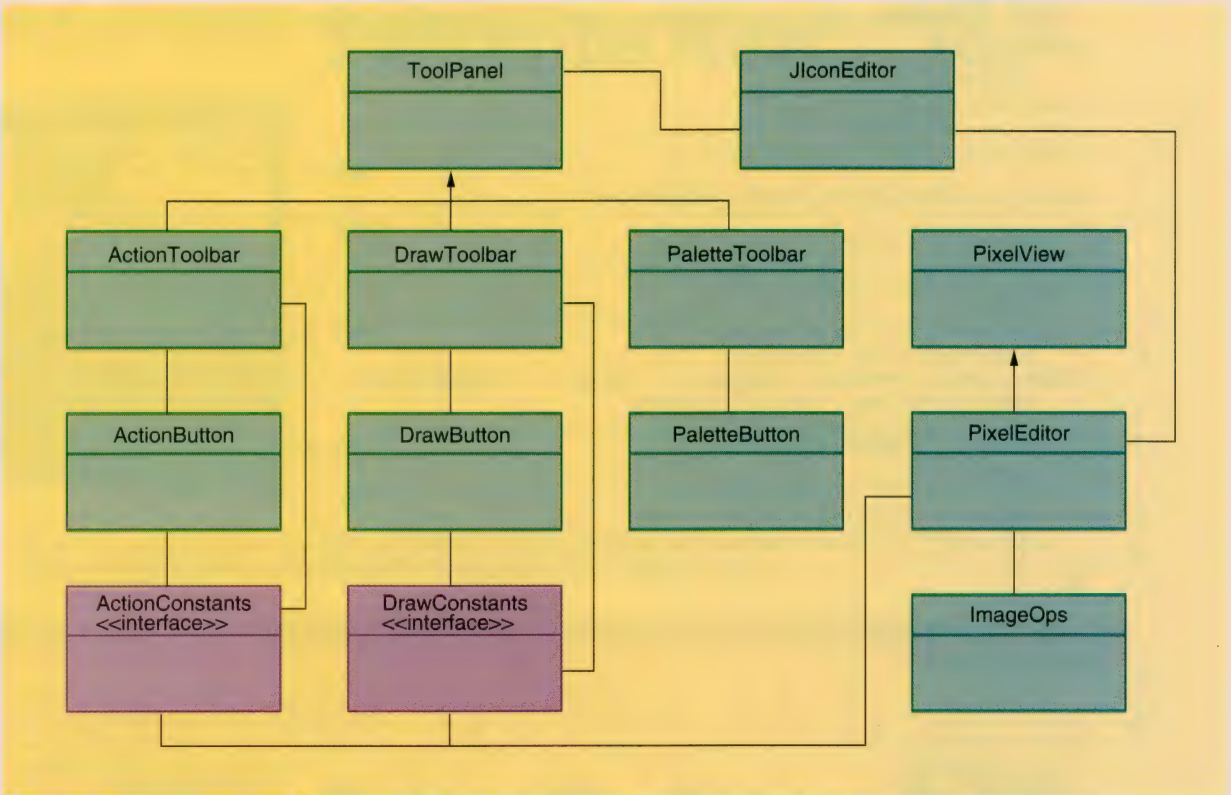

Figure 2 Class Relationships JIconEditor includes the following classes. It uses three toolbars derived from the ToolPanel class, each of which uses a specific type of button.

The DrawConstants serve a dual purpose. The constants remove any tight coupling to specific values and let us change the values without affecting behavior. They also store the prefix names for the icon files we intend to use. These are loaded by the DrawButton class, along with a suitable cursor image.

If you've never defined custom cursors, it's easy. The trick under Windows is to use the upper left 16×16 pixels in a 32×32 pixel image. Just use a GIF file and make the background transparent. This may work differently on other platforms according to the API documentation, but this technique was not obvious and required some experimentation. You can create custom cursors with the createCustomCursor() method in the AWT Toolbox class.

We use an ImageIcon to store both the Icon and Cursor images in DrawButton (see Listing 3). The preferred size and icons are set up in the constructor, along with a command name and a reference to the cursor for later use. We can get the cursor with a call to getToolCursor(). Be careful not to rename this to getCursor(), or you'll override the component-assigned cursor accessor and end up with confusing results. The only other thing to keep in mind with cursors is the hot spot, which is defined as specific pixel position for the pointer, typically the tip of an arrow or the bottom of an eye dropper, for example.

We define the hot spot as a point argument in DrawButton and set things up in the DrawToolbar class. Like PaletteToolbar, we use an array of constructed DrawButton elements and iterate through them to add, group, and register each button. DrawToolbar does some minor setup work, like setting the border and layout manager, and watches for button action events. When a button is pressed, we fire off an action event through the fireActionEvent() method inherited from ToolPalette.

The final toolbar is the ActionToolbar class, which uses the ActionConstants interface and ActionButton elements. These buttons take immediate action and are not mutually exclusive, so they

Figure 3 The Three Toolbars These are the three toolbars used in our implementation. The (a) DrawToolbar is responsible for selecting drawing tools; the (b) ActionToolbar triggers actions like flip or move; and the (c) PaletteToolbar lets you select the active color.

Listing 1 PaletteButton Class The PaletteToolbar uses a PaletteButton that extends JToggleButton so that we can make these members of a ButtonGroup.

```
import java.awt.*;
import java.awt.image.*;
import javax.swing.*;

public class PaletteButton extends JToggleButton
{
  protected Color color;

  public PaletteButton(Color color)
  {
    setPreferredSize(new Dimension(22, 22));
    setMaximumSize(new Dimension(22, 22));
    this.color = color;
    BufferedImage image = new BufferedImage(
      16, 16, BufferedImage.TYPE_INT_RGB);
    Graphics g = image.getGraphics();
    g.setColor(color);
    g.fillRect(0, 0, 16, 16);
    setIcon(new ImageIcon(image));
    setFocusPainted(false);
    setHorizontalAlignment(CENTER);
    setVerticalAlignment(CENTER);
  }

  public boolean isFocusTraversable()
  {
    return false;
  }

  public boolean isDefaultButton()
  {
    return false;
  }

  public Color getColor()
  {
    return color;
  }
}
```

Listing 2 PaletteToolbar Class The PaletteToolbar class implements the ActionListener interface and receives notification when a button is pressed.

```
import java.awt.*;
import java.awt.event.*;
import java.util.*;
import javax.swing.*;
import javax.swing.border.*;

public class PaletteToolbar extends ToolPanel
  implements ActionListener
{
  protected Color color;
  protected ArrayList listeners = new ArrayList();

  private PaletteButton[] buttons =
  {
    new PaletteButton(Color.red),
    new PaletteButton(Color.cyan),
    new PaletteButton(Color.black),
    new PaletteButton(Color.orange),
    new PaletteButton(Color.green),
    new PaletteButton(Color.magenta),
    new PaletteButton(Color.gray),
    new PaletteButton(Color.pink),
    new PaletteButton(Color.blue),
    new PaletteButton(Color.yellow),
    new PaletteButton(Color.white),
    new PaletteButton(Color.lightGray)
  };

  public PaletteToolbar()
  {
    setBorder(new CompoundBorder(
      new EtchedBorder(),
      new EmptyBorder(4, 4, 4, 4)));
    setLayout(new GridLayout(4, 3, 2, 2));
    ButtonGroup group = new ButtonGroup();
    for (int i = 0; i < buttons.length; i++)
    {
      add(buttons[i]);
      group.add(buttons[i]);
      buttons[i].addActionListener(this);
    }
  }

  public void actionPerformed(ActionEvent event)
  {
    PaletteButton button = (PaletteButton)event.getSource();
    color = button.getColor();
    fireActionEvent("Select");
  }

  public Color getColor()
  {
    return color;
  }
}
```

are not members of a ButtonGroup. In every other way, however, ActionToolbar is like DrawToolbar. The ActionButton is identical to a DrawButton, except for the need to store a cursor. Like the DrawConstants, the ActionConstants define file prefixes for the icons, but we don't expect any files with the Cursor suffix to be loaded.

Pixel Space

One key element of an icon editor is the pixel editing space. Our implementation uses two classes in the form of a PixelView, which lets us render pixel representations in a larger visible area, and a PixelEditor, which extends the PixelView by adding editing capabilities. This arrangement supports a nice separation of responsibilities and provides additional flexibility by promoting reuse should we decide in the future that we want a lightweight view without the editing features.

The PixelView source code is shown in Listing 4. The constructor expects a BufferedImage and a cell size value. The BufferedImage is our source image, which will be drawn by mapping each pixel to a larger square in a grid. Each pixel is drawn based on the specified cell size parameter and will be either the color of the pixel or a single small dot if the pixel is transparent. We store the image and cell size as instance variables to be used in our paint method.

To make sure we can use our PixelView with larger images, probably in a scroll view, we provide a getPreferredSize() method, which does a simple calculation based on the cell size and possible insets. It's important to consider insets if we want to respond correctly when a border is used.

Drawing pixels is a simple matter of iterating through the BufferedImage using the getRGB() method for each pixel position. Before we draw the pixels, our paintComponent() method draws vertical and horizontal grid lines. We delegate the pixel draw-

Continued on page 56.

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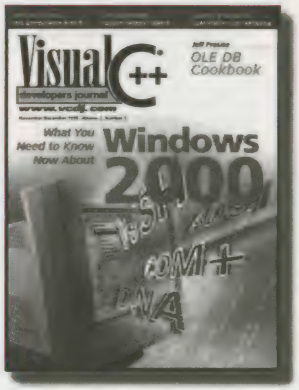

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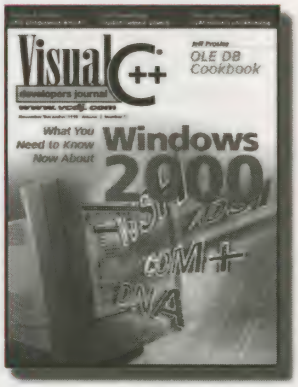

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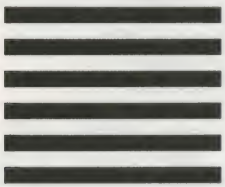

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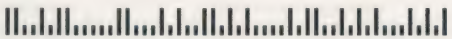

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Listing 3 DrawButton Class We use an ImageIcon to store both the Icon and Cursor images in DrawButton. The preferred size and icons are set up in the constructor, along with a command name and a reference to the cursor for later use.

```
import java.io.*;
import java.awt.*;
import javax.swing.*;

public class DrawButton extends JToggleButton
  implements DrawConstants
{
  protected String command;
  protected Cursor cursor;

  public DrawButton(String name, Point point)
  {
    String iconfile = "icons/" + name + "Icon.GIF";
    String cursfile = "icons/" + name + "Cursor.GIF";
    ImageIcon icon = new ImageIcon(iconfile);
    setIcon(icon);
    setPreferredSize(new Dimension(22, 22));
    setMaximumSize(new Dimension(22, 22));
    command = name;
    if ((new File(cursfile)).exists())
    {
      ImageIcon curs = new ImageIcon(cursfile);
      cursor = Toolkit.getDefaultToolkit().createCustomCursor(
        curs.getImage(), point, command);
    }
    else
      cursor = null;
    setFocusPainted(false);
  }

  public boolean isFocusTraversable()
  {
    return false;
  }

  public boolean isDefaultButton()
  {
    return false;
  }

  public String getCommand()
  {
    return command;
  }

  public Cursor getToolCursor()
  {
    if (cursor == null)
      return Cursor.getDefaultCursor();
    return cursor;
  }
}
```

Listing 4 PixelView Class The constructor in this class expects a BufferedImage and a cell size value.

```
import java.awt.*;
import java.awt.image.*;
import javax.swing.*;

public class PixelView extends JPanel
{
  protected int cellSize;
  protected BufferedImage image;

  public PixelView(BufferedImage image, int cellSize)
  {
    this.image = image;
    this.cellSize = cellSize;
  }

  public Dimension getPreferredSize()
  {
    Insets insets = getInsets();
    int width = image.getWidth();
    int height = image.getHeight();
    return new Dimension(
      insets.left + insets.right + width * cellSize + 1,
      insets.top + insets.bottom + height * cellSize + 1);
  }

  public void paintComponent(Graphics g)
  {
    int w = getSize().width;
    int h = getSize().height;
    g.setColor(getBackground());
    g.fillRect(0, 0, w, h);

    Insets insets = getInsets();
    int width = image.getWidth();
    int height = image.getHeight();

    // Draw grid
    g.setColor(Color.lightGray);
    for (int x = 0; x <= width; x++)
    {
      int offset = insets.left + x * cellSize;
      g.drawLine(offset, insets.top,
        offset, insets.top + height * cellSize);
    }
    for (int y = 0; y <= height; y++)
    {
      int offset = insets.top + y * cellSize;
      g.drawLine(insets.left, offset,
        insets.left + width * cellSize, offset);
    }
    // Draw cells
    for (int x = 0; x < width; x++)
    {
      for (int y = 0; y < height; y++)
      {
        drawCell(g, insets, x, y, image.getRGB(x, y));
      }
    }
  }

  protected void drawCell(Graphics g,
    Insets insets, int x, int y, int rgb)
  {
    int alpha = (rgb >> 24) & 0xff;
    if (alpha == 0)
    {
      g.setColor(getBackground());
      g.fillRect(
        insets.left + x * cellSize + 1,
        insets.top + y * cellSize + 1,
        cellSize - 1, cellSize - 1);
      g.setColor(Color.black);
      g.drawLine(
        insets.left + x * cellSize + (cellSize / 2),
        insets.top + y * cellSize + (cellSize / 2),
        insets.left + x * cellSize + (cellSize / 2),
        insets.top + y * cellSize + (cellSize / 2));
    }
    else
    {
      g.setColor(new Color(rgb));
      g.fillRect(
        insets.left + x * cellSize + 1,
        insets.top + y * cellSize + 1,
        cellSize - 1, cellSize - 1);
    }
  }
}
```

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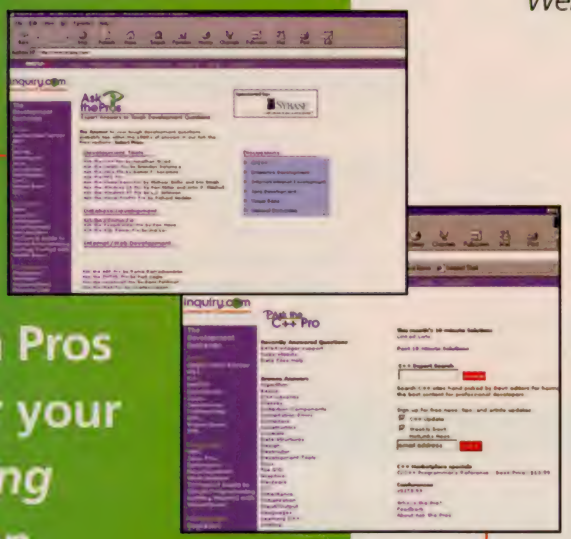

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Listing 5 PixelEditor Class This class extends PixelView and adds some useful behaviors.

```
import java.io.*;
import java.awt.*;
import java.awt.event.*;
import java.awt.image.*;
import javax.swing.*;
import javax.swing.border.*;

public class PixelEditor extends PixelView
  implements DrawConstants, ActionConstants,
    MouseListener, MouseMotionListener, ActionListener
{
  protected String activeTool = PENCIL;
  protected Color color = Color.blue;
  protected BufferedImage move;
  protected Rectangle drag;
  protected JLabel preview;
  protected ImageOps imageOps;
  protected JFileChooser fileChooser;

  public PixelEditor(BufferedImage image,
    int cellSize, JLabel preview)
  {
    super(image, cellSize);
    this.preview = preview;
    imageOps = new ImageOps();
    addMouseListener(this);
    setBorder(new EmptyBorder(4, 4, 4, 4));
    fileChooser = new JFileChooser();
    fileChooser.addChoosableFileFilter(new GIFFileFilter());
    fileChooser.setCurrentDirectory(new File("."));
  }

  protected void refresh()
  {
    repaint();
    preview.repaint();
  }

  public void paintComponent(Graphics g)
  {
    super.paintComponent(g);
    if (drag != null)
    {
      drawSelection(g, getInsets(), activeTool);
    }
  }

  protected void drawSelection(Graphics g,
    Insets insets, String selected)
  {
    g.setColor(color);
    int halfCell = cellSize / 2;
    int corner = cellSize * 3;
    Rectangle scaled = new Rectangle(
      insets.left + drag.x * cellSize + halfCell,
      insets.top + drag.y * cellSize + halfCell,
      drag.width * cellSize, drag.height * cellSize);
    if (selected == LINE)
    {
      g.drawLine(scaled.x, scaled.y,
        scaled.x + scaled.width,
        scaled.y + scaled.height);
    }
    if (selected == FILL_OVAL)
    {
      g.fillOval(scaled.x, scaled.y,
        scaled.width, scaled.height);
    }
    if (selected == OVAL ||
        selected == FILL_OVAL)
    {
      g.drawOval(scaled.x, scaled.y,
        scaled.width, scaled.height);
    }
    if (selected == FILL_RECT)
    {
      g.fillRect(scaled.x, scaled.y,
        scaled.width, scaled.height);
    }
    if (selected == RECT ||
        selected == FILL_RECT)
    {
      g.drawRect(scaled.x, scaled.y,
        scaled.width, scaled.height);
    }
    if (selected == FILL_ROUND_RECT)
    {
      g.fillRoundRect(scaled.x, scaled.y,
        scaled.width, scaled.height, corner, corner);
    }
    if (selected == ROUND_RECT ||
        selected == FILL_ROUND_RECT)
    {
      g.drawRoundRect(scaled.x, scaled.y,
        scaled.width, scaled.height, corner, corner);
    }
  }

  public void mouseClicked(MouseEvent event) {}
  public void mouseEntered(MouseEvent event) {}
  public void mouseExited(MouseEvent event) {}

  public void mouseReleased(MouseEvent event)
  {
    removeMouseMotionListener(this);
    if (drag != null)
    {
      Graphics2D g = (Graphics2D)image.getGraphics();
      g.setColor(color);
      g.setRenderingHint(
        RenderingHints.KEY_ANTIALIASING,
        RenderingHints.VALUE_ANTIALIAS_ON);
      if (activeTool == LINE)
      {
        g.drawLine(drag.x, drag.y,
          drag.x + drag.width, drag.y + drag.height);
      }
      if (activeTool == FILL_OVAL)
      {
        g.fillOval(drag.x, drag.y, drag.width, drag.height);
      }
      if (activeTool == OVAL ||
          activeTool == FILL_OVAL)
      {
        g.drawOval(drag.x, drag.y, drag.width, drag.height);
      }
      if (activeTool == FILL_RECT)
      {
        g.fillRect(drag.x, drag.y, drag.width, drag.height);
      }
      if (activeTool == RECT ||
          activeTool == FILL_RECT)
      {
        g.drawRect(drag.x, drag.y, drag.width, drag.height);
      }
      if (activeTool == FILL_ROUND_RECT)
      {
        g.fillRoundRect(drag.x, drag.y, drag.width,
          drag.height, 3, 3);
      }
      if (activeTool == ROUND_RECT ||
          activeTool == FILL_ROUND_RECT)
      {
        g.drawRoundRect(drag.x, drag.y, drag.width,
          drag.height, 3, 3);
      }
    }
```

Continued on page 54.

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Continued from page 52.

```
      move = null;
      drag = null;
      refresh();
    }

    public void mousePressed(MouseEvent event)
    {
      Insets insets = getInsets();
      int width = image.getWidth();
      int height = image.getHeight();
      int x = (event.getX() - insets.left) / width;
      int y = (event.getY() - insets.top) / height;
      if (activeTool.equals(PENCIL))
      {
        image.setRGB(x, y, color.getRGB());
      }
      if (activeTool.equals(ERASER))
      {
        image.setRGB(x, y, 0);
      }
      if (activeTool.equals(DROPPER))
      {
        color = new Color(image.getRGB(x, y));
      }
      if (activeTool.equals(PAINT))
      {
        imageOps.floodFill(image, x, y,
          image.getRGB(x, y), color.getRGB());
      }
      if (activeTool.equals(LINE) ||
          activeTool.equals(OVAL) ||
          activeTool.equals(FILL_OVAL) ||
          activeTool.equals(RECT) ||
          activeTool.equals(FILL_RECT) ||
          activeTool.equals(ROUND_RECT) ||
          activeTool.equals(FILL_ROUND_RECT))
      {
        int xa = (event.getX() - insets.left) / cellSize;
        int ya = (event.getY() - insets.top) / cellSize;
        drag = new Rectangle(xa, ya, 0, 0);
        addMouseMotionListener(this);
      }
      if (activeTool.equals(HAND))
      {
        int w = image.getWidth();
        int h = image.getHeight();
        move = new BufferedImage(
          w, h, BufferedImage.TYPE_INT_ARGB);
        Graphics g = move.getGraphics();
        g.drawImage(image, 0, 0, this);
        int xa = (event.getX() - insets.left) / cellSize;
        int ya = (event.getY() - insets.top) / cellSize;
        drag = new Rectangle(xa, ya, 0, 0);
        addMouseMotionListener(this);
      }
      refresh();
    }

    public void mouseMoved(MouseEvent event) {}
    public void mouseDragged(MouseEvent event)
    {
      Insets insets = getInsets();
      if (move != null)
      {
        int x = (event.getX() - insets.left) /
          cellSize - drag.x;
        int y = (event.getY() - insets.top) /
          cellSize - drag.y;
        int w = image.getWidth();
        int h = image.getHeight();
        image = new BufferedImage(
          w, h, BufferedImage.TYPE_INT_ARGB);
        Graphics g = image.getGraphics();
        g.drawImage(move, x, y, this);
        refresh();
      }
      if (drag != null)
      {
        int x = (event.getX() - insets.left) / cellSize;
        int y = (event.getY() - insets.top) / cellSize;
        drag.setSize(x - drag.x, y - drag.y);
        refresh();
      }
    }

    public void actionPerformed(ActionEvent event)
    {
      Object source = event.getSource();
      if (source instanceof PaletteToolbar)
      {
        PaletteToolbar palette = (PaletteToolbar)source;
        color = palette.getColor();
      }
      if (source instanceof DrawToolbar)
      {
        DrawToolbar tools = (DrawToolbar)source;
        activeTool = event.getActionCommand();
        setCursor(tools.getToolCursor());
      }
      if (source instanceof ActionToolbar)
      {
        ActionToolbar toolbar = (ActionToolbar)source;
        String command = event.getActionCommand();
        if (command.equals(MOVE_NORTH_WEST))
          image = imageOps.moveImage(image, -1, -1);
        if (command.equals(MOVE_NORTH))
          image = imageOps.moveImage(image, 0, -1);
        if (command.equals(MOVE_NORTH_EAST))
          image = imageOps.moveImage(image, 1, -1);
        if (command.equals(MOVE_WEST))
          image = imageOps.moveImage(image, -1, 0);
        if (command.equals(MOVE_EAST))
          image = imageOps.moveImage(image, 1, 0);
        if (command.equals(MOVE_SOUTH_WEST))
          image = imageOps.moveImage(image, -1, 1);
        if (command.equals(MOVE_SOUTH))
          image = imageOps.moveImage(image, 0, 1);
        if (command.equals(MOVE_SOUTH_EAST))
          image = imageOps.moveImage(image, 1, 1);
        if (command.equals(FLIP_VERT))
          image = imageOps.flipImage(image, ImageOps.VERTICAL);
        if (command.equals(FLIP_HORZ))
          image = imageOps.flipImage(
            image, ImageOps.HORIZONTAL);
        if (command.equals(ROTATE_RIGHT))
          image = imageOps.rotateImage(image, ImageOps.RIGHT);
        if (command.equals(ROTATE_LEFT))
          image = imageOps.rotateImage(image, ImageOps.LEFT);

        if (command.equals(NEW_FILE))
          newFile();
        if (command.equals(OPEN_FILE))
          openFile();
        if (command.equals(SAVE_FILE))
          saveFile();

        refresh();
      }
    }

    protected void newFile()
    {
      int w = image.getWidth();
      int h = image.getHeight();
      image = new BufferedImage(
        w, h, BufferedImage.TYPE_INT_ARGB);
      preview.setIcon(new ImageIcon(image));
      refresh();
```

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Continued from page 48.

ing to a method called drawPixel(), which decides whether to draw a filled-in square the color of the pixel or a small dot on a flat background if the alpha value is zero.

The PixelEditor, shown in Listing 5, extends the PixelView class and adds useful behaviors. Some of these are context-dependent and based on the active tool, driven by selections in the DrawToolbar. Whenever tools are selected, we receive an action event and, after determining which toolbar the event came from, either set the context or take immediate action. In the case of color selections or drawing tools, we set the color or the active tool. Drawing tools, as you may recall, also set the cursor.

The PixelEditor class processes mouse events. The mousePressed() events are triggers for drawing operations, such as drawing or erasing a single pixel or setting an anchor for an operation that relies on the mouse release position, such as drawing a line, oval, or rectangle. The first cases are easy and effectively complete by the time the mouse is released. Other cases involve mouse dragging and drawing a rubber band-style tracking shape.

The paintComponent() method calls the superclass to draw the grid and calls the drawSelection() method if the drag variable is not null. We always make sure it gets set to null intentionally when the mouse is released and the drawing complete. The drawSelection() method calculates the drawing rectangle and draws the outline of the selection based on the color and the drawing tool that was selected.

The mouseDragged() events handle selection and movement operations. Selection is simply a matter of moving the non-anchored corner of our selection and repainting. Movement requires making a copy of the image and drawing into it at the new position. We handle this, in part, with the mousePressed() event to copy the original image to be dragged, and, in part, with the mouseDragged event to position the image at the new location. You can see this behavior when you use the hand icon to drag the image around.

After the mouse is released, a drawing operation need only draw the line, oval, or rectangle outline, and possibly filled region, into the image buffer and the repaint takes care of the rest. While the selection drawing is done on the larger PixelView canvas, releas-

Listing 6 ImageOps Class All of these operations may be used in other contexts.

```
import java.awt.*;
import java.awt.image.*;
import javax.swing.*;

public class ImageOps implements SwingConstants
{
  protected BufferedImage moveImage(
    BufferedImage image, int x, int y)
  {
    int w = image.getWidth();
    int h = image.getHeight();
    BufferedImage buffer = new BufferedImage(
      w, h, BufferedImage.TYPE_INT_ARGB);
    Graphics gc = buffer.getGraphics();
    gc.drawImage(image, 0, 0, null);
    image = new BufferedImage(
      w, h, BufferedImage.TYPE_INT_ARGB);
    Graphics g = image.getGraphics();
    g.drawImage(buffer, x, y, null);
    return image;
  }

  protected BufferedImage flipImage(
    BufferedImage image, int direction)
  {
    int w = image.getWidth();
    int h = image.getHeight();
    BufferedImage buffer = new BufferedImage(
      w, h, BufferedImage.TYPE_INT_ARGB);
    Graphics gc = buffer.getGraphics();
    if (direction == HORIZONTAL)
      gc.drawImage(image, w, 0, 0, h, 0, 0, w, h, null);
    else
      gc.drawImage(image, 0, h, w, 0, 0, 0, w, h, null);
    image = new BufferedImage(
      w, h, BufferedImage.TYPE_INT_ARGB);
    Graphics g = image.getGraphics();
    g.drawImage(buffer, 0, 0, null);
    return image;
  }

  protected BufferedImage rotateImage(
    BufferedImage image, int direction)
  {
    int w = image.getWidth();
    int h = image.getHeight();
    BufferedImage buffer = new BufferedImage(
      w, h, BufferedImage.TYPE_INT_ARGB);
    Graphics2D gc = (Graphics2D)buffer.getGraphics();
    if (direction == RIGHT)
    {
      gc.translate(w, 0);
      gc.rotate(Math.PI / 2);
    }
    if (direction == LEFT)
    {
      gc.translate(0, h);
      gc.rotate(-(Math.PI / 2));
    }
    gc.drawImage(image, 0, 0, null);

    image = new BufferedImage(
      w, h, BufferedImage.TYPE_INT_ARGB);
    Graphics g = image.getGraphics();
    g.drawImage(buffer, 0, 0, null);
    return image;
  }

  protected void floodFill(BufferedImage buffer,
    int x, int y, int oldColor, int newColor)
  {
    int w = buffer.getWidth();
    int h = buffer.getHeight();
    if (y < 0 || y >= h) return;
    if (x < 0 || x >= w) return;
    int pos = x;
    while (buffer.getRGB(pos, y) == oldColor)
    {
      buffer.setRGB(pos, y, newColor);
      if (y > 0 && buffer.getRGB(pos, y - 1) == oldColor)
        floodFill(buffer, pos, y - 1, oldColor, newColor);
      if ((y + 1) < h && buffer.getRGB(pos, y + 1) == oldColor)
        floodFill(buffer, pos, y + 1, oldColor, newColor);
      pos--;
      if (pos < 0) break;
    }
    pos = x + 1;
    if (pos >= w) return;
    while (buffer.getRGB(pos, y) == oldColor)
    {
      buffer.setRGB(pos, y, newColor);
      if (y > 0 && buffer.getRGB(pos, y - 1) == oldColor)
        floodFill(buffer, pos, y - 1, oldColor, newColor);
      if ((y + 1) < h && buffer.getRGB(pos, y + 1) == oldColor)
        floodFill(buffer, pos, y + 1, oldColor, newColor);
      pos++;
      if (pos >= w) break;
    }
  }
}
```

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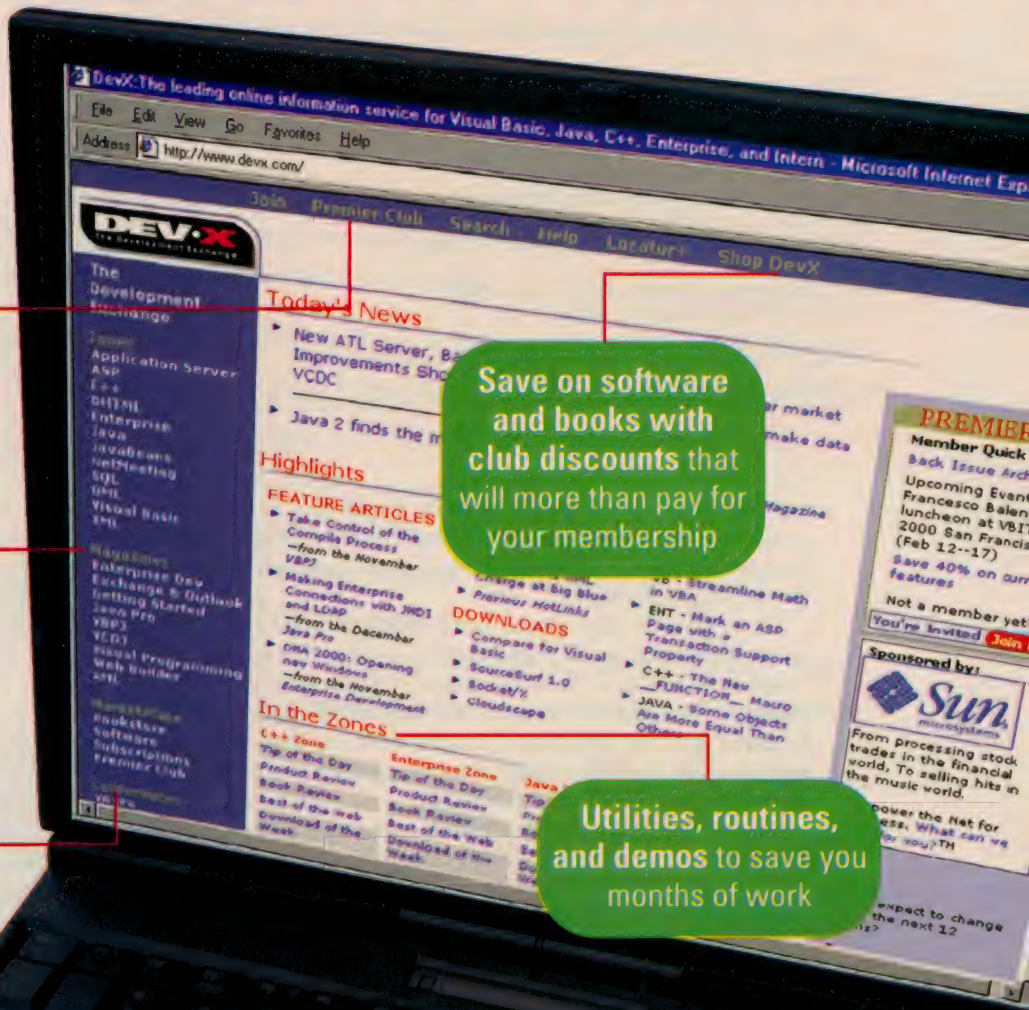
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Listing 7 JIconEditor Class The JIconEditor class implements the editor in a JPanel for convenience.

```
import java.awt.*;
import java.awt.event.*;
import java.awt.image.*;
import javax.swing.*;
import javax.swing.border.*;

public class JIconEditor extends JPanel
{
  public JIconEditor()
  {
    BufferedImage image = readBufferedImage(
      "icons/Computer.gif");

    setLayout(new BorderLayout());

    JPanel west = new JPanel(new BorderLayout());
    JPanel east = new JPanel(new BorderLayout());

    ToolPanel action = new ActionToolbar();
    ToolPanel draw = new DrawToolbar();
    JPanel westPanel = new JPanel(new BorderLayout());
    westPanel.add(BorderLayout.NORTH, action);
    westPanel.add(BorderLayout.SOUTH, draw);

    west.add(BorderLayout.NORTH, westPanel);
    add(BorderLayout.WEST, west);

    JLabel preview = new JLabel(new ImageIcon(image));
    preview.setPreferredSize(new Dimension(26, 26));
    preview.setBorder(BorderFactory.createEtchedBorder());

    ToolPanel palette = new PaletteToolbar();

    JPanel eastPanel = new JPanel(new BorderLayout());
    eastPanel.add(BorderLayout.NORTH, preview);
    eastPanel.add(BorderLayout.SOUTH, palette);

    east.add(BorderLayout.NORTH, eastPanel);
    add(BorderLayout.EAST, east);

    PixelEditor editor = new PixelEditor(image, 16, preview);
    add(BorderLayout.CENTER, new JScrollPane(editor));

    palette.addActionListener(editor);
    draw.addActionListener(editor);
    action.addActionListener(editor);
  }

  public BufferedImage readBufferedImage(String filename)
  {
    ImageIcon icon = new ImageIcon(filename);
    Image image = icon.getImage();
    BufferedImage buffer = new
      BufferedImage(image.getWidth(null),
      image.getHeight(null),BufferedImage.TYPE_INT_ARGB);
    Graphics g = buffer.getGraphics();
    g.drawImage(image, 0, 0, null);
    return buffer;
  }
}
```

ing the mouse causes painting to be transferred to the original image and the repaint causes the larger view to be updated to reflect the changes. We use the Java 2D antialiasing hints to make the drawing smoother.

The ActionToolbar events use a subclass called ImageOps to move, flip, rotate, or fill portions of an image. This helps keep the coupling looser and allows us to reuse image operations in other contexts. The only tricky operation is the floodFill algorithm, which required a lot of tweaking. I started with my own version, researched it on the Web to find something better, and found myself repairing the best version I found.

The floodFill algorithm is recursive and works by moving out from a center point in every direction. The center point moves around through recursive calls and works its way around corners to fill everything that touches the original pixel in the same color, except for diagonals. It may not be optimally efficient on very large images, but it works reliably in all cases and acts plenty fast for an icon editor.

All the operations in the ImageOps class (see Listing 6) operate on a BufferedImage and may be used in other contexts, making the code as reusable as possible. The PixelEditor is more tightly coupled to the operations it performs and could be improved by developing a model that delegates operations to other classes. I found the compromise between the number of classes, overall organization, and loose coupling reasonable at this level, though I might use keystroke mappings and Action objects in a future version.

Top of the Class

Listing 7 shows the JIconEditor class, which ties all this together, implementing the editor in a JPanel for convenience. The ActionToolbar and DrawToolbar are placed on the left and the PaletteToolbar on the right of a PixelView area. The PixelView is in a JScrollPane in the event that the image is too large to fit in the viewing area. With the real work delegated to subcomponents, there's nothing more than a constructor that positions the elements in a BorderLayout.

You'll find a JIconEditorTest class online when you pull the source code down. The main method simply creates a JFrame and puts a JIconEditor in the center. I found loading time to be slightly longer than I like because so many small images were loaded for the toolbar icons and cursors. This setup could be optimized by putting all the images together in a single image/grid and reconstructing the individual icons in memory.

JIconEditor is a useful tool for editing small images. The toolset is relatively comprehensive and provides considerable power to a user. This component is more of a small application than those we've visited in past installments, yet it provides a drop-in set of functionality that can help enhance your user experience. Don't drop an icon editor into an end-user application that doesn't need it, but if the moment is right, you know where to look for the tools. ■

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ImpureThoughts

Getting Sparse

Sparse matrices turn up in linear programming applications; these techniques will help you make the best of them

BY RICK GREHAN

On my way to explaining the Jama matrix algebra package in January's column, I took a peek at the structure of Java multidimensional arrays. Now it's time to examine a particular sort of 2D array that occurs frequently enough in linear programming applications that it warrants specialized storage techniques. That "particular sort" of 2D array is known as a sparse matrix.

The name says it all. A sparse matrix is sparsely populated. Most of its elements are zero. That being the case, if the matrix is large and we use a standard 2D array to store it, a lot of memory is used to store—well, nothing.

Of course, "large" is a relative term—especially in the computer world (where, a decade ago, a 100MB hard disk was regarded as "large"). Some large systems of linear equations can translate to a matrix with thousands of rows and columns. If such a matrix is sparse, the programmer should investigate ways to store that matrix other than a straightforward implementation as a 2D array.

It appears that we need a sparse matrix class that creates objects that, on the outside look to behave like a "normal" 2D array, but on the inside are more frugal with storage. I say "appears" because we can't override the array index operators in Java, so we have to be satisfied with accessor methods. In addition, some applications that use a sparse matrix are hampered if the matrix behaves like a normal array.

Hashtable

A first stab at managing a sparse matrix would be to create a kind of data structure that uses the row and column coordinates of the non-zero elements as a key into a database. The nonzero values would be the "payload" associated with the key. (Donald Knuth hints at this technique in Volume 1 of *The Art of Computer Programming*. We'll come back to this book later when we look at another sparse matrix data structure.)

In Java, it is easy to use the coordinates of the nonzero elements as a key into a database using the Hashtable class as the database mechanism. Listing 1 shows an example sparse matrix class implemented using a hashtable. It provides two accessor methods: get() and set(). The get() method is coded so that if a requested element isn't found in the array, it returns a 0. Furthermore, if you set() a nonzero element to zero, that element is removed from the hashtable.

This approach has its advantages and disadvantages. Perhaps the greatest advantage is that constructing it is simple. The hashtable key is simply a Long object that consists of the concatenated row and column values; the data item is the associated nonzero double value. Another advantage is that the Hashtable class provides insert and delete operations for which the coding is straightforward. The possible problems that arise from a collision (trying to insert a key/data whose key already exists in the table) is automatically handled by the Hashtable.put() method.

The not-so-obvious disadvantage is that this structure does not support fast row or column operations. To locate the next nonzero element in a row (or column), your program would have to query the hashtable repeatedly—either incrementing or decrementing the appropriate coordinate. The result, of course, would be piles and piles of "key not found" conditions until the program stumbled onto the next nonzero element. Why this might be important requires a brief detour.

Many linear algebra and linear programming operations on matrices involve algorithms that—at their heart—"walk" sequentially through a matrix row or column (or both). You'll find a classic example in the unadulterated matrix multiplication algorithm. Simply put, if you want to multiply two matrices A and B such that C=A×B, then the core formula is:

```
c[i][j] = a[i][0] * b[0][i] + a[i][1] *
  b[1][i] + ...
```

In other words, the result is the sum of the element-by-element multiplication of a row in A by a column in B. (Other algorithms for matrix multiplication reduce the number of multiplications and additions required. I've chosen the "classic" approach for illustration.)

If the matrices being multiplied are sparse and we use the Hashtable class approach for storage, it's easy to see that the algorithm will waste time wading through zeroes. Nevertheless, for applications in which the sparse matrix elements were accessed randomly, a hashtable approach is an easy-to-assemble solution. If the Hashtable class methods are implemented in na-

tive code, reading and writing sparse matrix elements should be acceptably quick.

Knuth's Web

One solution to our sparse matrix problem can be found if we return to *The Art of Computer Programming*, where Don Knuth describes a data structure that consists of interconnected linked lists. One set of lists wires the column elements together; another wires the row elements together.

A variation on Knuth's structure is implemented in Listing 2. (It's a variation because Knuth's lists cycle in the opposite direction from the one I've shown.) Figure 1 is a diagram of the data structure as it would appear for the simple 3×3 matrix:

```
1 0 0
0 2 0
0 0 0
```

Nonzero elements are stored in a "node," a data structure that consists of two link "pointers," a row and column coordinate, and a payload. Nonzero elements are connected along row and column, and each list is anchored by a node at the row head or column head.

The sparseMatrix class in Listing 2 provides methods for adding, removing, and retrieving elements from the matrix. The set() method is "smart" in that it properly handles the case of setting a nonzero element to zero; namely, it removes the element. I've also provided methods for locating the first and next elements in a row or column. With this structure, matrix multiplication would be less "wasteful," since the algorithm can quickly traverse rows and columns.

If the matrix is large and we use a standard 2D array to store it, a lot of memory is used to store—well, nothing

The class shown in Listing 2 simply allocates and de-allocates nodes (objects of type sparseElement) on the fly. If the values in a matrix are likely to change as the application runs, you can save time if the nodes are "pre-allocated" when the matrix is created. Nodes could be pulled from the pool as needed and returned to it when removed from the matrix. This would sidestep all the allocating and de-allocating that would otherwise take place, lightening the load on the garbage collector.

Compressed Coordinate Storage

Another technique that provides rapid access of sequential row and column members is a variation on the "coordinate storage"

Listing 1 Sparse Matrix Using a Hashtable Creating a class that uses a hashtable for sparse array access is straightforward. The row and column coordinates form the key, the nonzero value forms the data item. The hashtable handles the adding and removing of elements almost invisibly. (Note that, for speed's sake, the routine attaches no exceptions to index out-of-bounds conditions.)

```
import java.util.Hashtable;
//
// Class hashSparse
// Uses a hashtable as the storage mechanism
// for a sparse array.

class hashSparse {
  Hashtable shash;  // Hashtable
  int maxrow;       // Max row
  int maxcol;       // Max column

//
// Create a hashSparse array with max row and column
// given by mrow and mcol
public hashSparse(int mrow, int mcol)
{
  // Set max coords
  maxrow = mrow;
  maxcol = mcol;

  // Initialize the hashtable. We initialize with 100
  // elements and load factor of 0.80
  shash = new Hashtable(100, 0.80f);

  return;
}

//
// Set an item in the hashtable
// Ignore if out of bounds
// If we set an element to 0 and it exists,
// we delete the element
public void set(int row, int col, double val)
{
  long lkey; // For holding key

  // Check coords
  if((row >= maxrow) ||
    (row < 0) ||
    (col >=  maxcol) ||
    (col < 0))
    return;

  // Pack coordinates
  lkey=(long)row;
  Long key = new Long(lkey<<32 |
    (long)col);
  // If storing 0, issue a remove and return.
  if(val == (double)0.0)
  {
    shash.remove(key);
    return;
  }

  // Move val into Double object and put it in the table
  Double dval = new Double(val);
  shash.put(key,dval);
  return;
}

//
// Get an item from the hashtable
// Return 0 if out of bounds or if nothing at coordinates.
public double get(int row, int col)
{
  Double dval;
  long lkey;

  // Check coords
  if((row >= maxrow) ||
    (row < 0) ||
    (col >=  maxcol) ||
    (col < 0))
    return((double)0.0);

  // Create coordinate object and search
  lkey=(long)row;
  Long key = new Long(lkey<<32 |
    (long)col);
  dval = (Double)shash.get(key);
  if(dval == (Double)null)
    return((double)0.0);

  return(dval.doubleValue());
}
}
```

Listing 2 Sparse Matrix Using Linked Lists This code implements a "Knuth-like" sparse matrix of interconnected linked lists. Random access is not as good as with the code in Listing 1. However, this version of sparse matrix storage works well for algorithms that depend on sequential access of row and column members.

```
//
// Storage class for sparse matrix
//
public class sparseElement
{
  sparseElement right;  // Next element in row
  sparseElement down;   // Next element in column
  int row;              // Row coordinate
  int col;              // Column coordinate
  double val;           // Payload

public sparseElement()
{
  // Initialize rows and columns to -1. Useful for the
  // search algorithms
  row= -1;
  col= -1;
}
}

//
// Sparse Matrix class
// Modified "Knuth" style
//
public class sparseMatrix
{

  int rowmax;                // Max row
  int colmax;                // Max col
  sparseElement rowBase [];  // Row anchors
  sparseElement colBase [];  // Column anchors

  public sparseMatrix (int rows, int cols)
  {
    // Allocate row and column anchors
    rowBase = new sparseElement[rows];
    colBase = new sparseElement[cols];

    // Set row and column max
    rowmax = rows-1;
    colmax = cols-1;

    // Set row and col values in the anchors to -1. This
    // will help the insert algorithm
    for(int i=0; i<rows ; i++)
      rowBase[i] = new sparseElement();
    for(int i=0; i<cols ; i++)
      colBase[i] = new sparseElement();
  }

  // Add a sparseElement into the sparseMatrix. If the
  // sparseElement already exists at that coordinate,
  // this works like an update. If adding 0 and the
  // element exists, it is deleted.
  public void set (int row, int col, double val)
  {
    sparseElement elem;
    sparseElement next;
    sparseElement prev;

    // Verify in bounds -- ignore if not
    if((row < 0 ) || (row > rowmax) ||
      (col < 0) || (col > colmax))
      return;

    // Allocate and initialize element
    elem = new sparseElement();
    elem.row = row;
    elem.col = col;
    elem.val = val;

    // Wire into column. Examine column base "down" pointer.
    // If null, this is the only element. Otherwise, we have
    // to walk the list.
    if(colBase[col].down ==
      (sparseElement)null)
    { colBase[col].down = elem;
      elem.down = colBase[col];
    }
    else
    { prev = colBase[col];
      next = colBase[col].down;
      // Loop until the next element has bigger row
      // number (or -1)
      while((next.row <= row) &&
           (next.row != -1))
      { prev = next;
        next = prev.down;
      }
      // We're at the spot to insert. Verify that the element
      // doesn't already exist in the array. If it does, and
      // we are setting to zero -- delete it.
      if(prev.row==row)
      {
        if(val == (double)0.0)
          remove(prev);
        else
          prev.val=val;
        return;
      }
      // At this point, we have verified that the element
      // doesn't already exist. If we're setting to 0, exit
      if(val == (double)0.0)
        return;

      // Wire it in the column
      prev.down=elem;
      elem.down=next;
    }

    // Wire into row.
    if(rowBase[row].right ==
      (sparseElement)null)
    { rowBase[row].right = elem;
      elem.right = rowBase[row];
    }
    else
    { prev = rowBase[row];
      next = rowBase[row].right;
      // Loop as above
      while((next.col <= col ) &&
           (next.col != -1))
      { prev = next;
        next = prev.down;
      }
      // Don't have to check like above
      prev.right = elem;
      elem.right = next;
    }
    return;
  }

  // Remove sparseElement from sparseMatrix
  public void remove (sparseElement elem)
  {
    sparseElement next;

    // Loop through column, find previous element,
    // and disconnect
    next = elem.down;
    while(next.down != elem)
      next = next.down;
    next.down = elem.down;
    // Special case if we've emptied the whole column.
    if(next.col == -1)
      next.down = (sparseElement)null;

    // Loop through row
    next = elem.right;
```

Listing continued on page 64.

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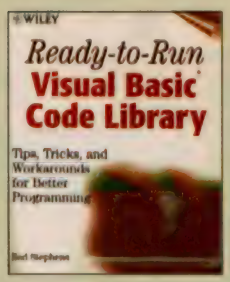

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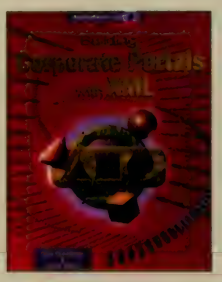

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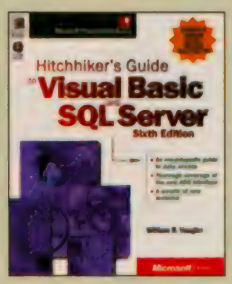

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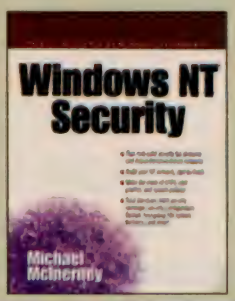

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theme. Coordinate storage rests on the idea that sparse matrix storage is a matter of storing the least amount of information needed to represent the matrix. On first glance, then, it seems that all we need to store for each nonzero element is its row coordinate, column coordinate, and data value. So, we could store our sparse matrix in three arrays: row[], col[], and val[]. The ith nonzero value would be stored by placing its row coordinate in row[i], its column coordinate in col[i], and its value in val[i].

What's important, of course, is how the nonzero items are arranged in the arrays. A purely random ordering of nonzero elements isn't worth much—searching for an item would require the code to walk through the array from one end to the other. (Since most searches into the arrays would turn up empty, a lot of time would be uselessly spent.)

Obviously, we should arrange the items either in row order or column order. Which arrangement we choose will be guided by the nature of the algorithms that access the matrix. Still, even if the elements were arranged in row order, locating the start of an arbitrary row would require a linear search into the row[] array.

It turns out that, with a minor modification, we can do the coordinate storage technique one better (both improving access and reducing memory needed). Suppose that you've got a sparse matrix that you want to store using a coordinate technique. Let's presume that it's a small sparse matrix:

Continued from page 62.

```
    while(next.right != elem)
      next = next.right;
    next.right = elem.right;
    // Special case
    if(next.row == -1)
      next.right = (sparseElement)null;
  }

  // Return a sparseElement at coordinates given. Go by row.
  // Return null if not in matrix
  public sparseElement atRow(int row, int col)
  {
    sparseElement next;

    // Verify in bounds. Return 0.0 if out of bounds
    if((row < 0 ) || (row > rowmax) ||
      (col < 0) || (col > colmax))
      return((sparseElement)null);

    next = rowBase[row].right;

    // Empty row?
    if(next == (sparseElement)null)
      return ((sparseElement)null);
    while((next.col < col) &&
          (next.col != -1))
      next = next.right;

    if(next.col == col)
      return next;
    else
      return((sparseElement)null);
  }

  // Return a sparseElement value at coordinates given.
  // Go by row.
  public double valRow(int row, int col)
  {
    sparseElement get;

    get=atRow(row,col);
    if(get==(sparseElement)null)
      return((double)0.0);

    return(get.val);
  }

  // Return a sparseElement at coordinates given.
  // Go by column. Return null if not in matrix
  public sparseElement atCol(int row, int col)
  {
    sparseElement next;

    // Verify in bounds
    if((row < 0 ) || (row > rowmax) ||
      (col < 0) || (col > colmax))
      return((sparseElement)null);

    next = colBase[col].down;

    // Empty col?
    if(next == (sparseElement)null)
      return((sparseElement)null);
    while((next.row < row) &&
          (next.row != -1))
      next = next.down;

    if(next.row == row)
      return next;
    else
      return((sparseElement)null);
  }

  // Return a sparseElement value at coordinates given.
  // Go by column.
  public double valCol(int row, int col)
  {
    sparseElement get;

    get=atCol(row,col);
    if(get==(sparseElement)null)
      return((double)0.0);

    return(get.val);
  }

  // Return the first sparseElement in a row.
  // Returns null if empty row
  public sparseElement firstInRow(int row)
  {
    return(rowBase[row].right);
  }

  // Return the next sparseElement in a row.
  // Returns null if at end of row
  public sparseElement
    nextInRow(sparseElement elem)
  {
    elem = elem.right;
    if(elem.row == -1)
      elem=(sparseElement)null;
    return(elem);
  }

  // Return the first sparseElement in a column.
  // Returns null if empty column
  public sparseElement firstInCol(int col)
  {
    return(colBase[col].down);
  }

  // Return the next sparseElement in a column.
  // Returns null if at end of column.
  public sparseElement
    nextInCol(sparseElement elem)
  {
    elem = elem.down;
    if(elem.col == -1)
      elem=(sparseElement)null;
    return(elem);
  }
}
```

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```
0 0 1 0
2 0 0 3
0 3 3 0
2 0 0 0
```

Storing this matrix by row using coordinate storage would look like this:

```
row[] = { 0, 1, 1, 2, 2, 3 }
col[] = { 2, 0, 3, 1, 2, 0 }
val[] =  { 1, 2, 3, 3, 3, 2 }
```

Notice that the row[] array has repeated entries for rows 1 and 2. We can eliminate the extra entries if we use what's called (in this instance) compressed row storage. It's a simple idea, and it hinges on turning the row[] array into an array of (gasp) pointers into the col[] and val[] arrays. It requires a change only in the row[] array:

```
row[] = {0, 1, 3, 5 }
col[] = { 2, 0, 3, 1, 2, 0 }
val[] =  { 1, 2, 3, 3, 3, 2 }
```

Now, the ith entry in the row[] array corresponds to the ith row (rather than the ith nonzero value in the sparse matrix). In addition, each entry in row[] holds an index into the col[] and val[] arrays where the nonzero column coordinate and data values are stored.

Read it like this: row[]=0 means that col[0] holds the column coordinate and val[0] holds the value for the first nonzero element in the first row. row[1]=1 means that col[1] holds the column coordinate and val[1] holds the value for the first nonzero element in the second row. row[2]=3 means that the information (column coordinates and values) for row three "starts" in col[3] and val[3], respectively. (This also means that the second row has two nonzero values.)

In short, the row[] array has only as many entries as there are rows in the matrix—rather than as many as there are nonzero values. Although in our example the storage saving isn't much, it can amount to several hundred KB on, say, a 100,000×100,000 sparse matrix (depending on how sparse the matrix is).

Finally, locating the start of a particular row is fast. In the matrix multiplication example, if you stored the A matrix in compressed row fashion and the B matrix in compressed column fashion, the multiplication algorithm becomes simple and fast. In fact, this technique is used by the SciMark Java benchmark (found at http://math.nist.gov/scimark/).

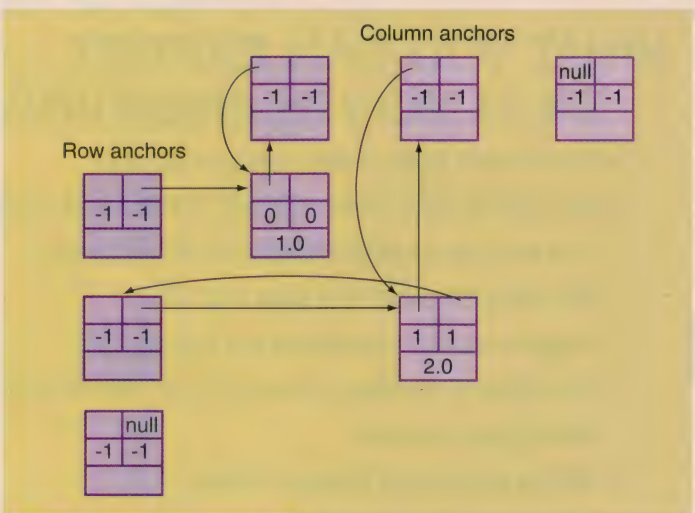

Figure 1 A 3×3 Array in Java This is the sparse matrix data structure implemented by the code in Listing 2. This structure is based on a structure presented by Donald Knuth (see text). Knuth's structure has the row and column anchors pointing to the last elements in the row and column; this structure points them to the first. (Knuth arranged his structure to simplify the coding of a pivot algorithm that appears in conjunction with the data structure.) This structure provides good sequential access of matrix elements: that is, you can quickly find the first and next elements in a row or column. Random access is not so fast, since it requires walking lists that can be arbitrarily long.

Lava Rocks

A final storage technique for sparse arrays that I want to mention is one I stumbled across on the Internet. This technique is probably more accurately called a virtual paged byte array; it was devised by Charlton Rose for his "Lava Rocks" Java class library (available at http://sharkysoft.com).

Lava Rocks includes useful classes, such as a Java equivalent to printf(), file utilities for reading and writing .WAV files, and classes for manipulating arrays. The Lava Rocks ByteArray32 class creates a large (2^{32} entry) virtual byte array.

When you create a ByteArray32 object, it builds a 256-element array of references to objects of class ByteArray24. An object of class ByteArray24 creates a 256-element array of objects of class ByteArray16, each object of which creates a 256-element array of objects of class ByteArray8—which finally creates an array of 256 bytes. The result of these nested arrays—if you can hold it all in your head—is a virtual array of $256\times256\times256\times256=2^{32}$ bytes.

However, what makes this a virtual array is that, upon creation, only the "topmost" array (ByteArray32) is actually instantiated—and the members of that array are null. No actual byte array is allocated. A read operation on the array returns 0. (The ByteArray32 get() method returns 0 for any byte element requested that is not yet allocated.)

The "lowmost" byte arrays that hold nonzero values—and the intervening reference arrays—are allocated only when a nonzero byte is written. The ByteArray32 set() method handles all the appropriate housekeeping of allocating (instantiating, if you will) the necessary arrays. The upshot is that you have a kind of "paged" virtual array (a page being a block of 256 bytes) of 2^{32} bytes with reasonably quick access speed, given that a search for an item requires following a chain of up to four references.

While the Lava Rocks' "virtual paged" array is specialized to bytes, it would be an easy matter to extend it to other data types. In addition, it's really a large 1D array of bytes, and its allocation is coarser than the other techniques I've shown (it allocates whole rows at a time).

Still, even if the Lava Rocks byte array doesn't solve your problem, there are enough techniques to choose from so that if you ever do encounter a sparse array, the odds are good that you can deal with it without exhausting memory. ■

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Continued from page 72.

A At least one checkbox in a CheckboxGroup must be selected at all times. A CheckboxGroup mimics a set of radio buttons, where the pressing of a button results in the ejection of all other buttons. In general, if you require all of your checkboxes to be deselected, it is possible that they really should not be in a CheckboxGroup. However, if the options represented by the checkboxes are indeed mutually exclusive, and you really would like to be able to deselect all of them, you can use the following trick: Add an extra checkbox to the CheckboxGroup, but don't add it to a container component and don't display it. When you want to deselect all the visible checkboxes, just set the invisible checkbox's state to true. From a user interface design standpoint, it may be better to make this extra button visible and give it a label like "None" so that it is clear to the user that it is possible not to choose any of the other options.

Q When a request message is processed through the HttpServlet doGet() method, who sets the parameters and attributes for the HttpServletRequest argument? What is the difference between an attribute and a parameter?

A Client requests are passed on to a servlet through the Web server's servlet engine. The servlet engine packages the request into a ServletRequest object, through which request attributes and parameters can be extracted. The HttpServlet class examines the request and repackages it as an HttpServletRequest before dispatching it to one of its do() methods, such as doGet(). Attributes provide a means for the Web server to give a servlet extra information about a request. They do not represent data that was sent directly from the client. Parameters are akin to function arguments. They are name value pairs transmitted by the client and interpreted by the servlet. For example, the values submitted through an HTML form would be passed as parameters that could be accessed through the HttpServletRequest argument to doGet().

Q Is there a way to declare and invoke methods in JavaServer Pages?

A Methods can be declared in the same way as variables in JavaServer Pages. It can help to think of JSP as a convenient syntax for defining servlets. Any variables or methods that you declare are members of the servlet. The syntax for making declarations in JSP is: <%! declaration %> You can access the declared variables and methods in any expression or scriptlet block. See Listing 1 for an example.

Listing 1 I Do Declare This example shows how to declare a method and invoke it in a JSP expression.

```
<html>
<body>

<!-- Declare a method. -->

<%!
  public String aMethod() {
    return "<b>A String.</b>";
  }
%>

This JSP page demonstrates how to declare and invoke a
method.
The next line is the output of calling aMethod():
<br>
<p>
<!-- Inline the output of an expression. -->

<%= aMethod() %>

</body>
</html>
```

Q We use applets to allow users to access a database, but are looking for ways to improve performance. Is a servlet-based solution faster than an applet-based solution?

A This will depend on the application, the number of concurrent clients, the average network latency and bandwidth between a client and the server, and other factors. In general, if you want your application to scale to large numbers of users, you will want to forego the applet-centric solution. If each client applet has to create a separate connection to the database, transfer data, and process it locally, you face several potential bottlenecks. First, you could overload your database with too many connections. Second, you may have to transfer a lot of data over the network, which may take a long time. Third, the client may not have enough processing power or memory to process all of the data in a timely manner, if at all. Other problems also exist, such as the inability to centralize business logic, leading to software maintenance difficulties.

Always recompile code that may be dependent on a modified class

The preferred design for such a system is a three-tier architecture. A three-tier system consists of a client, a middle layer that performs transaction processing, and a back-end server. The client is usually lightweight, able only to issue queries and receive final results. An example of this would be a simple HTML form. The middle layer's job is to mediate access to server resources and possibly perform processing on the client's behalf. The server, of course, stores the database or other service that the client ultimately wants to access. Additional data processing can happen on the server and extra tiers can be added if multiple resources need to be accessed.

Multitier architectures offer several advantages. The primary advantage is the ability to scale to larger numbers of clients. The transaction processing layer makes this possible. It can keep a pool of open connections to the server, using them as appropriate to serve client requests, saving the overhead of opening a new connection for every client. Rather than overloading the server with queries, the transaction processor can throttle back the load on the server by serializing requests. Data processing can also be removed from the client and pushed closer to the data. The second major advantage is the ability to subdivide software development cleanly. Each layer performs a well-specified task that can be developed without overly impacting the other layers.

Q I recently heard Enterprise JavaBeans are not fully portable. Is this true?

A The Enterprise JavaBeans specification allows the EJB Container Provider to use either the JDK 1.1 or Java 2 APIs. This introduces the possibility that Enterprise JavaBeans won't run in all EJB runtime environments. To guarantee portability, you should restrict yourself to the 1.1 APIs. However, I would venture that most vendors will support Java 2, and it is probably not worth sacrificing the use of Java 2 features for the sake of guaranteed portability.

Other characteristics of the EJB runtime environment affect EJB portability. For example, an EJB Container may use multiple JVMs to execute Beans, which would render reliance on single JVM synchronization mechanisms and shared static variables nonportable. For a complete description of the programming guidelines you should follow to write portable Enterprise JavaBeans, read Chapter 18 of the Enterprise JavaBeans Specification.

Q How do you determine when a client has closed its socket so that a server can cease to wait for messages from that client?

A When a socket endpoint closes its socket, a read on the InputStream at the other end will return –1, indicating end of file. If the process crashes, the same will happen because the operating system will close the socket when the process dies. However, if the

Listing 2 The Reconstruction Era This code gives an example of how to convert a class instance to a byte array and then reconstruct the original class from the byte array.

```
import java.io.*;

public class ByteSerialize {

  public static void main(String[] args) {
    Integer write, read;
    ObjectOutputStream out;
    ObjectInputStream in;
    ByteArrayOutputStream byteStream;
    byte[] bytes;

    write = new Integer(5);

    System.out.println("write: " + write);

    try {
      byteStream = new ByteArrayOutputStream();
      out = new ObjectOutputStream(byteStream);
      out.writeObject(write);
      out.close();

      // Byte representation of integer
      bytes = byteStream.toByteArray();

      in = new ObjectInputStream(new ByteArrayInputStream(bytes));
      read = (Integer)in.readObject();
      in.close();
    } catch(IOException ioe) {
      ioe.printStackTrace();
      return;
    } catch(ClassNotFoundException cnfe) {
      cnfe.printStackTrace();
      return;
    } catch(ClassCastException cce) {
      cce.printStackTrace();
      return;
    }

    System.out.println("read : " + read);

  }
}
```


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Listing 3 Testing the Behavior This program enables you to test the behavior of java.awt.Scrollbar compared to javax.swing.JScrollBar.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class ScrollTest {

  public static class ScrollTestComponent extends JPanel
    implements AdjustmentListener
  {
    JTextArea _scrollText;
    Scrollbar _scrollBar;
    JScrollBar _jscrollBar;

    public ScrollTestComponent() {
      _scrollBar = new Scrollbar();
      _jscrollBar = new JScrollBar();
      _scrollBar.addAdjustmentListener(this);
      _jscrollBar.addAdjustmentListener(this);
      _scrollText = new JTextArea(40, 40);
      _scrollText.setEditable(false);
      setLayout(new BorderLayout());
      add(_scrollBar, BorderLayout.WEST);
      add(_scrollText, BorderLayout.CENTER);
      add(_jscrollBar, BorderLayout.EAST);
      printScrollValues();
    }

    public void printScrollValues() {
      _scrollText.setText("    ScrollBar: ");

_scrollText.append(Integer.toString(_scrollBar.getValue()));
      _scrollText.append("\n    JScrollBar: ");

_scrollText.append(Integer.toString(_jscrollBar.getValue()));
    }

    public void adjustmentValueChanged(AdjustmentEvent e) {
      printScrollValues();
    }

  }

  public static void main(String[] args) {
    JFrame frame = new JFrame("Scroll Test");
    WindowListener exitListener;

    exitListener = new WindowAdapter() {
      public void windowClosing(WindowEvent e) {
        Window window = e.getWindow();
        window.setVisible(false);
        window.dispose();
        System.exit(0);
      }
    };

    frame.addWindowListener(exitListener);

    frame.getContentPane().add(new ScrollTestComponent(),
      BorderLayout.CENTER);
    frame.pack();
    frame.setVisible(true);
  }
}
```

process's host crashes, there is no way to detect the endpoint termination. With native system programming, it is possible to set the SO_KEEPALIVE socket option to test the integrity of a connection on a more frequent basis than the default two hours. Java does not allow you to do this, and instead relies on the system default.

Q Can I finalize an object without waiting for the garbage collector?

A The System class contains a convenience method called gc() that can be used to ask the JVM to run the garbage collector. It also contains a method called runFinalization(), which can be invoked to ask the JVM to perform all pending finalizations. These methods are the equivalent of calling Runtime.getRuntime() and invoking the corresponding method on the resulting Runtime instance. To finalize objects that are no longer referenced, you would call System.gc() to find all unreferenced objects and then System.runFinalization() to perform finalizations. However, garbage collection and finalization are not guaranteed to occur after calling these methods. The methods only specify that the JVM will make a best effort to complete the requested actions.

Q How can I convert a class instance to a byte array and then subsequently reconstruct the original class from the byte array?

A Java's Object Serialization API allows you to write class instances to streams. To store a class instance in a byte array, you can wrap a ByteArrayOutputStream with an ObjectOutputStream. To read a class instance from a byte array, you can wrap an ObjectInputStream with a ByteArrayInputStream. You just have to remember that all serializable objects must implement the Serializable interface. Listing 2 demonstrates how to do this.

Q I have an application that uses dialup networking. If I connect after starting my application, InetAddress.getLocalHost() always returns 127.0.0.1. Even if I connect before starting up, then disconnect and reconnect, the IP address I was assigned on the first connection by PPP is returned and not the new one. Why does this happen?

A I have taken some jabs at the java.net package, either from a design perspective or to criticize the JDK implementation. You've just run into another poorly conceived implementation detail. The InetAddress class in JDKs 1.0.2 and 1.1.x misguidedly caches hostname lookups in a hashtable. When a lookup is performed, the cache is checked first. If the entry is not in the cache, native DNS resolution is performed.

The flaw with this implementation is that it leads exactly to the problem you've encountered. If the hostname to IP address mapping of the local host changes, it will not be reported. In principle, it may be all right to do this because DNS servers cache mappings for set periods of time and will not reflect changes instantly. But long-lived Java applications will become victims of outdated information stored in their hashtable. JDK 1.2 tries to improve the situation by storing cache entries in a HashMap and giving each cache entry an expiration time. However, the fundamental problem is still there.

Rather than provide an extra layer of name resolution caching in InetAddress, the JDK implementation should rely on the native name resolution mechanisms that already have performance optimizations built in. In my opinion, you're dealing with a bug and the only way around it is to fiddle with the JDK classes. The JDK 1.2 implementation should at least give you control over the caching policy and expiration time, but it doesn't.

Q Being an advanced C++ user, I like to simplify code and often use operator overloading. Is it possible to overload operators in Java?

A C++ programmers moving to Java ask this question frequently, so it bears repeating the answer. Java does not support operator overloading. Operator overloading is mostly a syntactic convenience and could be added to the language relatively easily. The Java Community Process has no proposals to add op-

erator overloading to the language, but a generic types proposal has been approved, so it is possible that operator overloading could make its way into the language. For the moment, you either have to live without operator overloading, or try out a nonstandard Java derivative, such as the JFront preprocessor (www.winternet.com/~gginc/jfront/), which adds limited support for operator overloading.

Q Can I dynamically determine the value of a Scrollbar when I scroll? The adjustmentValueChanged() method gets called only when you stop scrolling. But I want to catch the value of the scrollbar when I press on the scrollbar and drag it. Is there a way to do this?

A You pay a price for the cross-platform portability of Java. Your code may compile once and run everywhere, but it may not behave the same way on every platform. The Scrollbar class is an AWT component whose ultimate representation and behavior is determined by a native peer. In Windows 95, you may find that the behavior of a Scrollbar is to notify its listeners of a change in value only after it has finished moving, rather than smoothly as it is moving. In a Unix/Motif environment, I find that each time the Scrollbar moves a unit increment, the listener is notified. Rather than rely on native peers, it is better to use the Java Foundation Classes, specifically the Swing package, to guarantee consistent behavior across platforms. The example program shown in Listing 3 allows you to test the behavior of java.awt.Scrollbar versus that of javax.swing.JScrollBar. A listener is registered with a scrollbar of each type and prints out the scrollbar values each time it is notified of a change through the AdjustmentListener interface.

Q Does each instance of a class have its own copies of instance methods in the same way it has its own copies of instance variables?

A Every time you instantiate a class, new memory is allocated to store the object. Part of this storage includes space for copies of its member variables. Rather than create a new copy of each method into a class instance, which would be expensive, a virtual lookup table mapping methods to code blocks is allocated. You can think of class methods as functions that take an invisible argument that references the invoking instance—that is, the "this" reference. That makes it possible to store methods independent of instantiated classes. When a class instance invokes a method, a lookup is performed in its virtual function table to find the proper code block to execute. Therefore, all class instances share the same code, but have their own data. Novel runtime optimization techniques have been applied to improve the performance of virtual function lookups in Java so that you only pay a lookup penalty the first time you invoke a method. ■

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Ask the Java Pro

Inveighing against Insidious Inlining

Despite productivity gains, Java programming is not without its share of headaches. I get bitten by unexpected problems every time a new JDK is released. My latest JDK upgrade trouble is the sort of thing that makes me think that someone has it in for me. Usually I can take comfort in the fact that at least a handful, if not a horde, of programmers around the world has encountered a problem before me. Sometimes, though, I suspect a conspiracy of silence over some particularly painful bugs.

The detailed workings of the Java compiler remain a mystery. Whereas C and C++ compilers possess many optimization options, the JDK compiler has only one, the –O flag. What exactly the –O flag does is not well documented. Among its many effects is the ability to inline functions under certain conditions. Typically, if the source code for a class is available to the JDK compiler while it compiles another class, it will attempt to inline invocations of final methods. Given Java's dynamic binding, this behavior is suspect. Suppose you change the method and recompile its class, but don't recompile the calling class. The calling class will now execute incorrectly, a situation that could have been avoided by not inlining the method. The lesson here is that you should not rely on dynamic binding to allow you to upgrade a library transparently without recompiling an application. Always recompile code that may be dependent on a modified class.

Cross-platform testing is just as important in Java as in any other language

BY DANIEL F. SAVARESE

An equally vexing problem is a direct byproduct of the method inlining performed by the JDK compiler's –O option and an unexpected interaction with the Java Security Manager. As you likely know, one of Java's more highly touted features is its capability for security. When a class is loaded or code is executed, all sorts of security checks can occur to ensure that no untrusted actions occur.

Part of the security checking process is class verification. Class verification ensures that a class file is properly formatted and does not perform any operations disallowed by the Java virtual machine. Unlike C++, where language-specified protections such as class member access are enforced at compile time, Java verifies some of these things at runtime. For example, a top-level class is not allowed to access another top-level class's private members. Even though a Java compiler is not supposed to generate such code, it is possible to construct a class file where this occurs. When loading a class for the first time, the JVM class verifier can check to see if any access violations occur within a class, and, if so, abort execution.

The key word in that last sentence is *can*. The JVM class verifier *can* check for access violations, but may not necessarily do so. As it turns out, the JDK 1.1.x runtimes did not check for access violations, or at least for classes illegally accessing the private member variables of other classes. I discovered this oversight when I started getting a stream of bug reports from developers using code that I had developed with the JDK 1.1.7 compiler. They all complained that the JDK 1.2 runtime (still in beta at the time) threw an IllegalAccessError when executing my code.

It turned out that the JDK 1.1.7 compiler was overzealous in its optimizations, generating class files that wouldn't pass the JDK 1.2 runtime's class verifier. The culprit was a final method that returned the value of a private variable. The 1.1.7 compiler inlined this method when called from another class, creating an illegal access to a private member variable in the class file's byte code. The 1.1.7 runtime never detected this because its class verifier did not check for this particular access violation. However, the 1.2 runtime did perform this check, causing a lot of problems for developers and making me look bad in the process.

I could have detected the problem if I had upgraded my development environment more aggressively at the time or at least performed regression testing each time a new JDK was released. I had not thought to do this because we're led to believe that all of our Java code is write once, run anywhere. But that's clearly not always the case. We are also led to believe that Java enhances our productivity, not only because of the language design, but also because of its cross-platform nature. However, cross-platform testing is just as important in Java as in any other language. Testing across multiple JVMs on the same platform is also incredibly important. All that development time you save may just balance out the added time the software testing division has to spend to make sure your code works everywhere.

Q How can I put all the checkboxes in a CheckboxGroup into an unselected state when Checkbox.setState(false) does not automatically deselect the checkbox once it has been selected.

Continued on page 68.

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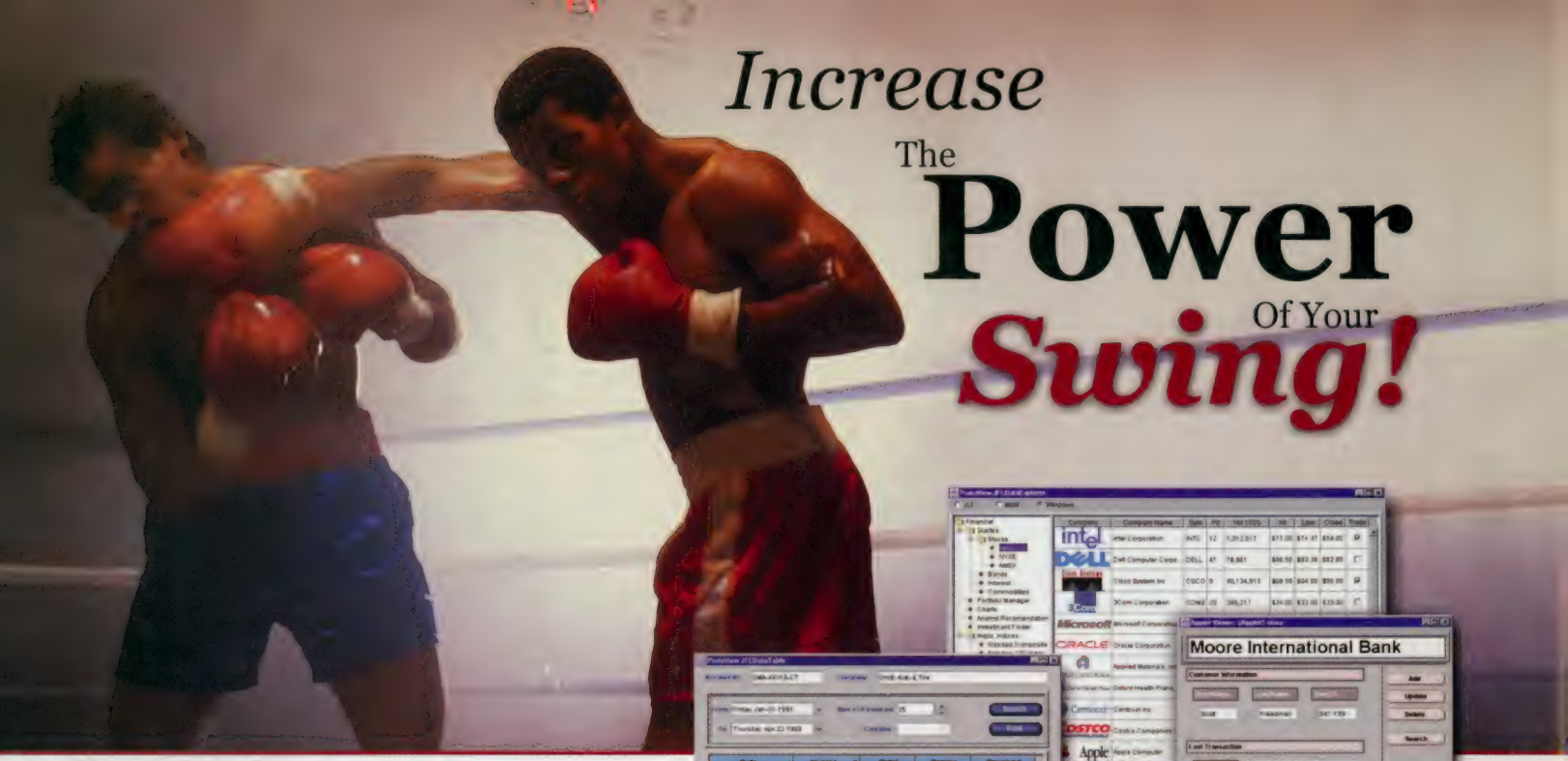

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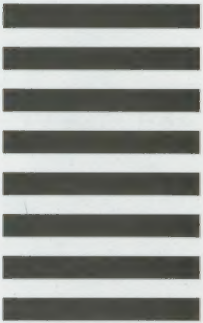

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